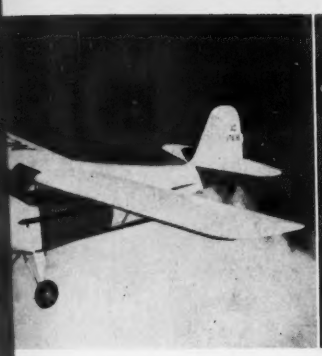
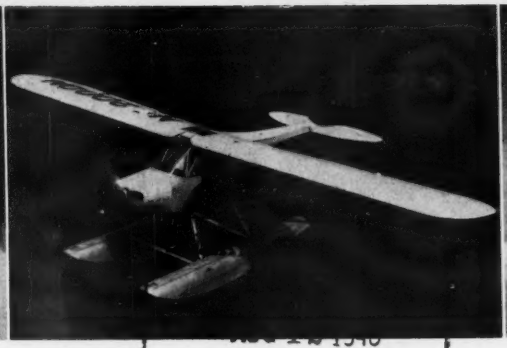
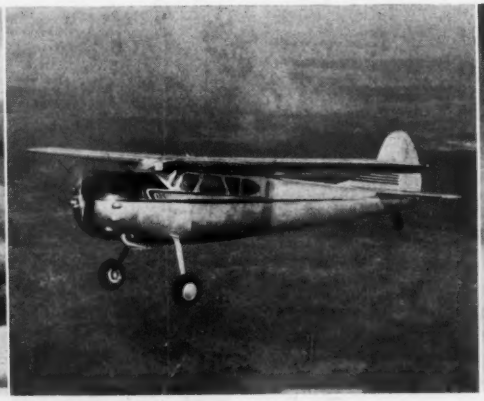
AERONAUTICAL ENGINEERING REVIEW

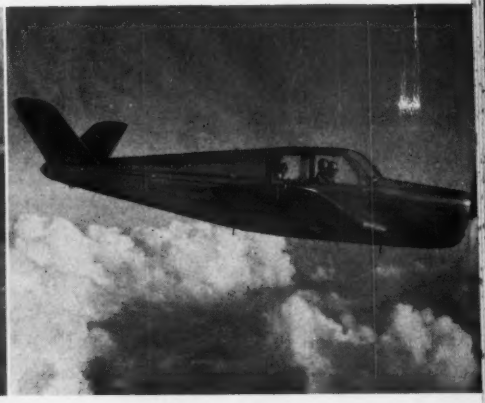
AUGUST 1948





First I.A.S "Meeting on Wings"





Report on Fifth Annual Personal Plane Meeting

etroit, June 7 Wichita, June 9 Dayton, June 10

PIONEER FLIGHT PATH CONTROL

YOU'VE SEEN THIS AD BEFORE—we repeat it
salute to the CAA whose ever progressive directora
of civil aviation has sponsored the stepping stone
flight despite the weather—the Instrument Landi
System, upon which is based the Flight Path Cont
System for fully automatic landing approaches—t
combined systems to be demonstrated in a series
"no hands" landing approaches on a regularly schedul
basis, regardless of weather, at International
Exposition, Idlewild Airport, July 31 through August

The ability to bring in every scheduled flight automatically, accurately, every time—the ability to fly a range automatically, unerringly, all the way—these advantages are bound to mean more exact airline operation. And that is just what Pioneer* offers in its new PB-10 Automatic Pilot with Flight Path Control. Utilizing the established C.A.A. instrument landing system beams, this Control flies the airplane on a smooth, sure flight over a VHF range, down the glide path for an accurate approach right to th runway. Its action is gentle but precise, as it automatical corrects for drift and maintains the plane on the exa center of the beam. Aside from its obvious savings in sche uled operations, it is also a valuable addition to fligh security and passenger comfort.

*REG. U. S. PAT.

***AUTOMATIC* Beam Entry ★ *AUTOMATIC* Beam Bracketing ★ *AUTOMATIC* Drift Correction ★ *AUTOMATIC* Landing Approach ★ *AUTOMATIC* Range Flyi**

Eclipse-Pioneer
TETERBORO, NEW JERSEY

DIVISION OF Bendix
AVIATION CORPORATION

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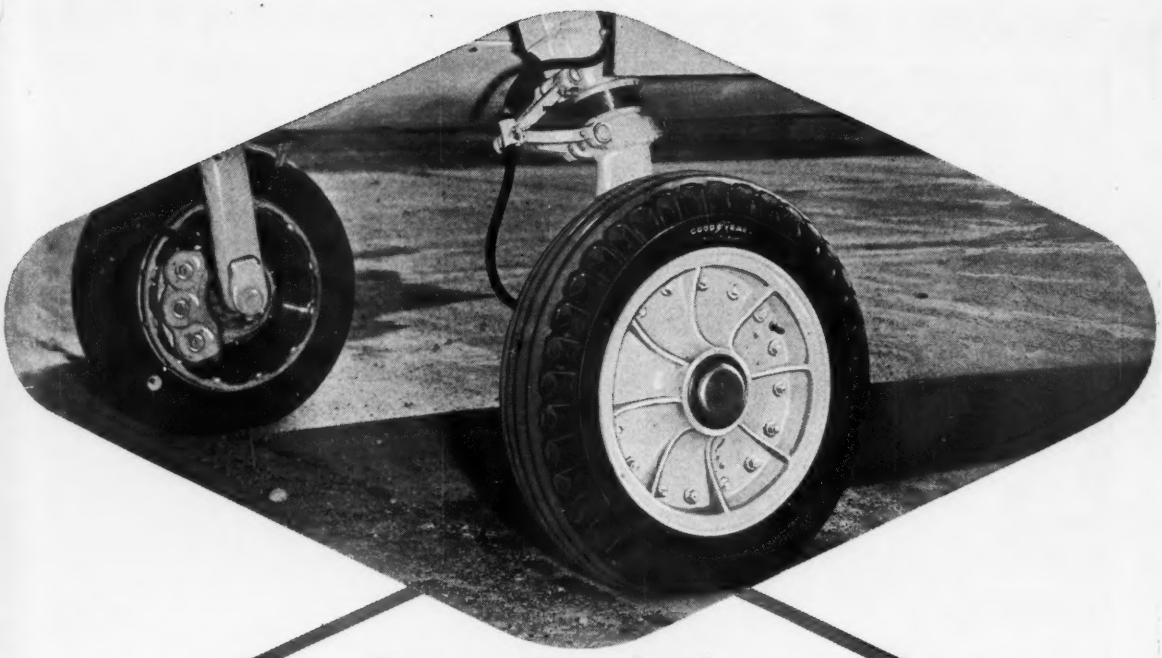


Super-Tough Tires

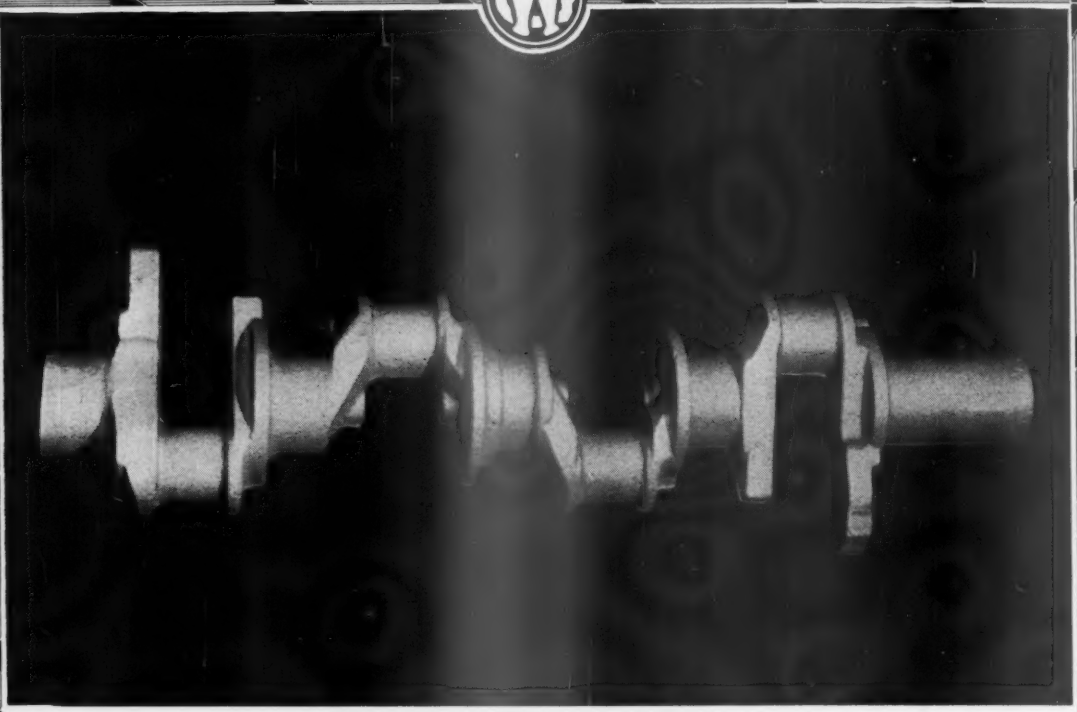
meet Skyrocket needs

The Skyrocket — Navy-Douglas high-speed research plane — presents tremendous landing-wheel problems. Tires, wheels and brakes must be lightweight, yet super-tough to take terrific take-off and landing speeds. That's why Goodyear extra-high-pressure tires, Goodyear magnesium alloy wheels and Goodyear Single Disc Brakes are used — they combine extra ruggedness, longer life and greater wear. Because Goodyear makes the right kind of landing-gear equipment for every type of ship, Goodyear Aviation Products are first choice with aircraft manufacturers and airline operators alike. For complete information about Goodyear Aviation Products, write: Goodyear, Aviation Products Division, Akron 16, Ohio, or Los Angeles 54, California.

GOODYEAR
AVIATION
PRODUCTS

NATIONAL AIR RACES
1948
CLEVELAND SEPT 4-5-6

MORE AIRCRAFT LAND ON GOODYEAR TIRES THAN ON ANY OTHER KIND



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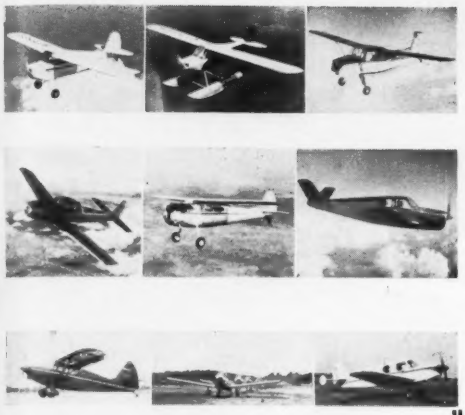

Cover—Typical personal airplanes of the present day

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AERONAUTICAL ENGINEERING REVIEW

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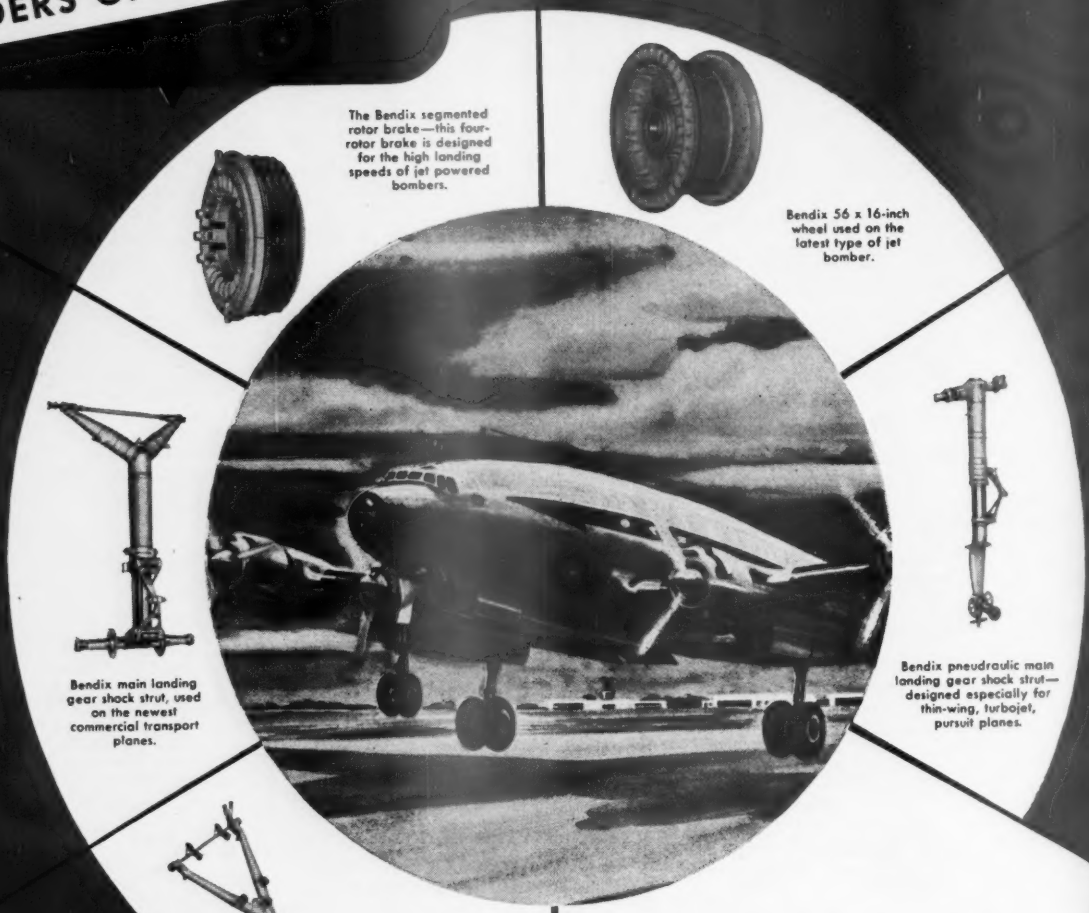
Published Monthly by the Institute of the Aeronautical Sciences, Inc.

Bendix Products

BUILDERS OF BASICALLY BETTER LANDING GEAR EQUIPMENT



The Bendix segmented rotor brake—this four-rotor brake is designed for the high landing speeds of jet powered bombers.

Bendix 56 x 16-inch wheel used on the latest type of jet bomber.

Bendix main landing gear shock strut, used on the newest commercial transport planes.

Bendix pneudraulic main landing gear shock strut—designed especially for thin-wing, turbojet, pursuit planes.

Bendix commercial transport nose strut, companion to the main landing shock strut shown above.

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BENDIX PRODUCTS

DIVISION of

I.A.S. News

A Record of People and Events of Interest to Institute Members

I.A.S.-Soaring Society Meet

First Postwar Joint Meeting of the Institute of the Aeronautical Sciences and Soaring Society of America Held at Elmira, July 1; Captain Barnaby Chairmans Symposium on Sailplane Performance Possibilities.

THE FIFTEENTH ANNUAL SOARING MEET of the Soaring Society of America (June 30–July 16) included a joint meeting on July 1 with the Institute at Elmira, N.Y. During "I.A.S. Day," which was the first collaboration with the S.S.A. undertaken by the Institute since before the war, I.A.S. members were able to inspect the latest sailplanes and gliders assembled on Harris Hill.

In the evening a buffet dinner was served in the Warren Eaton Memorial Building, followed by a Symposium on "Ultimate Performance Possibilities for Sailplanes," Chairman of which was Capt. Ralph S. Barnaby, U.S.N. (Ret.), Head, Aeronautics Section, Franklin Institute Laboratories for Research & Development.

▸ **Symposium Panel**—The panel for the Symposium consisted of the following:

• **August Raspet,** Technical Director, Soaring Society of America, and Research Director, Aero Physics Institute, who presented a paper entitled, "The Ultimate Performance Sailplane."

• **Alexander M. Lippisch,** Aerodynamicist, who spoke on "Aerodynamics and Control."

• **Stanley W. Smith,** Project Engineer, Bell Aircraft Corporation, "Structural Problems."

• **Ernest Schweizer,** President and Chief Engineer, Schweizer Aircraft Corporation, "Design Problems."

• **Robert C. Kidder,** Flight Research Engineer, Cornell Aeronautical Laboratory, "Performance Calculations and Flight Test."

• **A. F. Donovan** and **Dr. W. B. Klemperer,** Head, Aero-Mechanics Department, Cornell Aeronautical Lab., and Research Engineer, Douglas Aircraft Company, Inc. (Santa Monica), respectively, who presented a "Résumé."

T. P. Wright, President of Cornell Aeronautical Laboratory, Inc., and Vice-President of Cornell University, was present.

▸ **Keynote Address**—S.S.A. Technical Director Raspet keynoted the Symposium by stating the basic problems in attaining a sailplane of maximum performance.

"In designing a high performance sailplane," he said, "its function must first be determined—whether it is to be used in an attempt to break the world's distance record over the central plains, or to compete in a contest in the continental air mass."

Three types of stable sailplanes have been built, he said: the Penaud (tail-behind-wing); the Canard (tail first); and the tailless. Although the tailless involves stability problems not easily solved, "it does offer excellent promise where high cruising speeds are of paramount importance."

Continuing, Mr. Raspet discussed the possibilities of laminar-flow wing applications, boundary-layer control, speed range, and effects of ambient temperature on performance.

In conclusion he declared it was doubtful whether any sailplane will incorporate for a long time to come all the features that contribute to ultimate performance and that, furthermore, new developments in aeronautics may and should happen to make these features obsolete.

Symposium Chairman: *Capt. Ralph S. Barnaby, Head of Franklin Institute's Aeronautical Section, chairmanned joint S.S.A.-I.A.S. Sailplane Symposium.*

A more complete story, covering highlights of the technical sessions and discussions, will appear in the September issue of the REVIEW.

National Meetings Calendar

December 17	Wright Brothers Lecture, Washington, D.C.
January 24–27	Seventeenth Annual Meeting, New York

For details see page 32.

Leroy R. Grumman
. . . "for outstanding achievement in successfully advancing aircraft design both for Naval and peacetime use."

1948 Guggenheim Medalist

The 1948 Daniel Guggenheim Medal, given for notable achievements in the advancement of aeronautics, has been awarded to Leroy R. Grumman, Chairman of the Board of Grumman Aircraft Engineering Corporation.

▶**High Aeronautical Honor**—The selection of the recipient for this high American aeronautical honor is made by a board of 21 members, consisting of former recipients of the medal and representatives of The American Society of Mechanical Engineers, the Society of Automotive Engineers, the Institute of the Aeronautical Sciences, and the United Engineering Trustees. The medal and a certificate were awarded to Mr. Grumman for "outstanding achievement in successfully advancing aircraft design both for Naval and peacetime use."

▶ **Noted for Carrier Aircraft Development**—Grumman is noted for the development of carrier-based aircraft: the TBF "Avenger," standard Allied torpedo bomber from the time of the Battle of Midway till V-J Day; and the series of famous Cats—F4F "Wildcat," which was featured in the early days of the war in the epics of Wake Island and Guadalcanal; the F6F "Hellcat," which earned for Grumman the reputation of "Japanese Public Enemy No. 1"; the F7F "Tigercat," largest and deadliest carrier-based fighter of the recent war; and, finally, the F8F "Bearcat," a propeller-driven aircraft with a speed of 455 m.p.h.

On the civilian side, Grumman amphibian aircraft are owned by many companies and private owners.

A Fellow of the Institute of the Aeronautical Sciences, Mr. Grumman also is a member of the Society of Automotive Engineers; is a member of the Greater Cornell Committee, participating in the organization of the Cornell Aeronautical Laboratory; and is Rear Commodore of the Manhasset Bay Yacht Club..

Bassett Elected Sperry V.-P.

Preston R. Bassett, F.I.A.S., and President of the Sperry Gyroscope Company, was elected a Vice-President of The Sperry Corporation, it was announced in June. He will continue to head the Sperry Gyroscope Company division.

▶ **Many contributions**—Mr. Bassett, whose great interest has been in the field of air transportation, has made many contributions to the aeronautical sciences. As early as 1915 he worked on the development of some of the first flight instruments to be carried by aircraft.

During World War I he developed the high-intensity antiaircraft searchlight, and after that war he helped set up the first night airway for the Air Mail, developing beacons and airport floodlights. In addition, he directed development of the Sperry blind-flying instruments, the gyrohorizon and directional gyro, now standard equipment on transport and military planes. Under his direction also the Sperry Gyropilot for automatic flying was developed.

One of the first engineers to become interested in passenger comfort in aircraft, Bassett was responsible for the first successful system for soundproofing planes.

▶ **Amherst Graduate**—A graduate of Amherst College in 1913 with an A.B. degree, and subsequently an M.A., Mr. Bassett did postgraduate engineering at Brooklyn Polytech. He joined Sperry Gyroscope as research engineer in 1914. He became chief engineer in 1929 and Vice-President of the company in 1932. Elected General Manager in 1944, Bassett was named President in November of the following year.

Mr. Bassett, who served as 1947 President of the Institute, is a fellow of the American Association for Advancement of Science and American Physical Society. Other memberships include American Society of Naval Engineers and American Ordnance Association.

Discuss Aeronautical Education at I.A.S. in New York

Leading educators and members of the aircraft industry discussed future educational requirements in the field of aeronautics June 18 at the Institute of the Aeronautical Sciences in New York City under sponsorship of The National Air Council.

S. Paul Johnston, I.A.S. Director, acted as coordinator of the meeting.

Among those taking part in the roundtable discussion were: Dr. Leslie A. Bryan, Director of Institute of Aeronautics, University of Illinois; Frank W. Caldwell, Director of Research, United Aircraft Corporation; Charles H. Colvin, I.A.S. Past-President (1945), who also was the I.A.S. representative at the Mechanical Engineering Education Conference sponsored by The American Society of Mechanical Engineers last March; Dr. R. Paul Harrington, Department of Aeronautical Engineering, Polytechnic Institute of Brooklyn; Dr. John R. Markham, Professor of Aeronautical Engineering, M.I.T.; Dr. Clark B. Millikan, Acting Director, Guggenheim Aeronautical Laboratory, CalTech; H. E. Mehrens, Chief of the Aviation Education Division of the Civil Aeronautics Administration; William K. Ebel, Director of Engineering, Curtiss-Wright Corporation; and Dr. Daniel C. Sayre, Chairman, Department of Aeronautical Engineering, Princeton University.

Five I.A.S. Members Elected Royal Aeronautical Society Fellows

The Council of the Royal Aeronautical Society of London has elected five members of the Institute to Fellowships in the R.Ae.S., it has been announced by J. Laurence Pritchard, Secretary of the Society and I.A.S. Honorary Member.

The new R.Ae.S. Fellows are: Clark B. Millikan, Acting Director, Daniel Guggenheim Aeronautical Laboratory, CalTech; John D. Akerman, Professor of Aeronautical Engineering, University of Minnesota; John Joseph Green, Chief Research Aeronautical Engineer, Air Transport Board, Ottawa, Canada; Nicholas J. Hoff, Professor of Aeronautical Engineering, Polytechnic Institute of Brooklyn; and Major Gustavus McAlpine, Consultant, Hants., England.

Gardner Presents Gifts at M.I.T. "Aerial Shower"

Major Lester D. Gardner, I.A.S. founder, presented gifts flown from all parts of the world to Massachusetts Institute of Technology for the first "aerial shower" ever held. The "shower" was given in honor of Mrs. Karl T. Compton, wife of the President of M.I.T., by the Class of 1898, which celebrated its 50th anniversary during the annual alumni reunion.

In presenting the gifts to Mrs. Compton, Major Gardner recalled that in 1914 M.I.T. started the first course in aeronautical engineering. As early as 1911, he said, plans were formulated for a wind tunnel, and in 1913 lectures on aeronautics were already being given.

The gifts were sent by the great air lines of the world, both American and foreign, in recognition of M.I.T.'s pioneering contributions to the advancement of aviation.

No Ersatz

Dr. Hugh L. Dryden, Honorary Fellow and National Advisory Committee for Aeronautics Director, flatly termed untrue published reports that the Bell X-1 supersonic test plane is a copy of a German rocket plane.

The X-1, he said, was developed by Bell Aircraft from an N.A.C.A. design that was on the drawing board in 1944.

4 Lines Fly 4 Billion Miles Without Fatal Accident

Four air-line Corporate Members of the Institute have flown between them more than 4 billion passenger-miles without a fatality, it was revealed by the National Safety Council's 1947 aviation safety awards in June. Two of them, American Airlines System and Northwest Airlines, Inc., had reached the billion-mile mark since their last fatal accidents. The other, Pan American World Airways System, was honored for having passed the billion-mile mark before its no-accident record ended in 1947.

▶ **Operation Records**—Outstanding for fatality-free passenger-miles flown were:

- **American Airlines System** (New York)—One year and 1,502,499,000 passenger-miles since last fatal accident December 28, 1946.
- **American Overseas Airlines, Inc.** (New York)—One year and 206,385,000 passenger-miles since last fatal accident October 3, 1946.
- **Northwest Airlines, Inc.** (St. Paul)—Five years and 1,228,604,000 passenger-miles since last fatal accident May 12, 1942.
- **Pan American Airways, Inc.** (New York)—1,443,699,000 passenger-miles flown between August 3, 1945, and June 19, 1947, without a fatal accident.

All awards were made on the basis of official records of the Civil Aeronautics Board, and total miles were those accumulated in scheduled passenger-carrying operations only.

I.A.S. Newslines

▶ Commercial edition of *Practical Air Navigation* (C.A.B. 24), prepared by **Thoburn Cassady Lyon,** Associate Fellow, has been published. Five previous editions published by the Government totaled well over a million copies. Mr. Lyon is now engaged in the preparation of other texts in the field of air navigation and cartography, and in the compilation and drafting of maps and charts.

▶ Directors of Fairchild Engine & Airplane Corporation elected **George F. Chapline** to new post of Vice-President. He is an Associate Fellow and General Manager of Ranger Aircraft Division.

▶ Development of long-range B-52 bomber by Boeing was revealed by **Maj. Gen. L. C. Craigie,** I.A.S. Honorary Member and A.F. Director of Research and Development, before House Subcommittee of Committee on Appropriations. Powered by four turbo props, it will be in the 375,000-lb. class.

▶ Appointed by President Truman, **Hall L. Hibbard,** a Fellow, served as the aircraft industry adviser to the U.S. Delegation attending the second annual assembly of the International

World's First Aerial Shower: *The first aerial shower in the world was given during commencement at the Massachusetts Institute of Technology at Cambridge, Mass. Major Lester D. Gardner, I.A.S. Fellow and Chairman of the 50th Year Class, which gave the shower, presented gifts flown from all parts of the world to Mrs. Karl T. Compton, wife of the President of M.I.T., in recognition of M.I.T.'s contributions to the aeronautical sciences. Left to right: Rear Adm. Luis de Florez, I.A.S. Fellow who piloted the amphibian plane from New York on the last lap of the air trip of the presents; Major Gardner; Mrs. Compton; and President Karl T. Compton, a Fellow. Mrs. Compton stands on a rug flown from Iceland, wears an orchid lei from Honolulu, and holds a parasol from Japan, a silver box from Peru, shamrocks from Ireland, and heather from Scotland.*

20TH ANNIVERSARY
Twenty Years of BRANIFF Friendly Transportation
1928 ☆ 1948

...and for all 20 years
BRANIFF has
Consistently used
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spark plugs

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AIRCRAFT SPARK PLUGS

THE BG CORPORATION
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SERVING WORLD AVIATION OVER THIRTY YEARS

New Curtiss-Wright V.-P.: *Election of C. C. Pearson as Vice-President of the Curtiss-Wright Corporation has been announced by Guy W. Vaughan, President. Active in aviation for 18 years, Mr. Pearson, prior to joining Curtiss-Wright, was an executive of Douglas Aircraft. During the war he was Manager of the Douglas plant at Oklahoma City, which produced 5,000 C-47 and R-4D aircraft.*

Civil Aviation Organization at Geneva, which started June 1. He is Vice-President and Chief Engineer, Lockheed Aircraft.

▶ Past Chairman, Detroit Section I.A.S., **Thomas N. Kelly,** an Associate Fellow, has been appointed Chief Engineer and Assistant General Manager of the Smith-Morris Company, manufacturers of aircraft exhaust systems. He previously was Project Engineer for Continental Aviation & Engineering Corporation and is Assistant Vice-Chairman, Aeronautics Activity, Detroit Section S.A.E. for 1948–1949.

▶ One out of five "had" it. . .Each year, one in every four or five insured planes is involved in an accident to the tune of about 30 per cent of the aircraft's value, said **Jerry Lederer,** President of Flight Safety Foundation, speaking at 5th New England Aviation Conference. Mr. Lederer, a Fellow, urged all airport operators to achieve accident-free operation by personally and actively checking flight instructors' ability, field personnel, soft spots and obstructions in fields, refueling, fire hazards, and pilot information bulletins.

▶ Associate Fellow **Dr. Stefan Neumark,** part-time Professor at Polish University College, London, England, has been promoted to Principal Scientific Officer, Royal Aircraft Establishment, Farnborough, Hants., England.

▶ Warmly praised. . .**Dean George B. Pegram** of the graduate faculties of Columbia University, an Honorary Member of the Institute, was warmly praised for his long services to scholarship and to Columbia at the annual commencement luncheon of the Columbia Alumni Federation last June.

▶ Navy BuAer representative at Dayton, **Rear Adm. Frederick W. Pennoyer, Jr.,** an I.A.S. Fellow, became commander of the Navy Air Material Center at Philadelphia in July.

▶ Associate Fellow **Jean Alfred Roche** has been named Aeronautical Development Engineer, A.M.C. Engineering Liaison Office at N.A.C.A. Laboratory, Langley Air Force Base.

▶ Writing a book. . .**Gen. Carl A. Spaatz,** at a National Press Club Luncheon given in honor of his retirement, said his immediate plans include writing a book—he positively would not take a job in industry. General Spaatz, an Honorary Member of the Institute, predicted that the Air Force would have supersonic fighter aircraft within "a very few years." The General received a third Oak Leaf Cluster to his Distinguished Service Medal from the President late in May.

▶ Experimenting. . .**William B. Stout,** a Fellow, is establishing a small laboratory for further experimental work. He has been Consultant—Research Division, Consolidated Vultee Aircraft Corporation.

▶ Promoted. . .**Robert J. Woods** of Bell Aircraft Corporation was promoted to position of Chief Design Engineer early in June, President Lawrence D. Bell announced.

▶ In and out. . .**T. P. Wright,** Honorary Fellow and former C.A.A. head, who was replaced as C.A.A. member on National Advisory Committee for Aeronautics by Delos W. Rentzel, new C.A.A. Administrator, was resworn as a member from private life. He takes the place of the late Dr. Orville Wright.

Corporate Member News

• General Tire's **Aerojet Engineering Corporation** is transferring the research work it has been doing at Navy-owned plant in Pasadena to new location at former Phillips Aviation Company plant leased by General Tire. New plant will employ about 250 persons. Main Aerojet works are at Azusa, Calif.

• First jet engine ever to receive C.A.A. approval for commercial air transport operation, the Allison Model 400-C4 (J-33-21), built by **Allison Division,** General Motors, will be turned over to civilian manufacturers, although it will remain restricted until a later model is in production for the military.

• New $3,000,000 hangar at Chicago Municipal Airport has been completely activated by **American Airlines System.** Providing more than 2 acres of space, the structure is 620 ft. long, 240 ft. deep and consists of two bays, each affording a clear span of 275 ft. and depth of 175 ft. Six DC-6's and two Convair-Liners can be serviced simultaneously in each bay.

• New officers for **American Overseas Airlines** were announced, with Ralph S. Damon, F.I.A.S., who was re-elected President of American Airlines System, named Vice-President of A.O.A.

• U.S. Air Force has announced that its new J47A jet engine, the **General Electric Company's** TG-190A, was test flown May 20. Developing approximately 5,000-lb. thrust, most significant features are design and engineering changes that have made its rated thrust 25 per cent greater than the J-35 with substantially the same weight.

• Romec Pump acquired by Lear. . .All assets of Romec Pump Company, Elyria, Ohio, have been acquired by **Lear, Inc.,** which will operate the company as the Romec Pump Company Division of Lear, Inc.

• Wins U.S.A.F. safety pennants. . .Perfect F-80 flying safety record during first quarter of 1948 brought recognition to **Lockheed Aircraft Corporation** from Air Materiel Command when two green pennants were awarded the company. Pennants were presented to flight and maintenance personnel at Lockheed's Plant B-9.

• To start build-up for production of new-type plane. . .**North American Aviation, Inc.,** following an arrangement with Consolidated Vultee Aircraft for 3-year lease of Consolidated's portion of plant facilities at Vultee Field, is transferring its Aerophysics Department to Downey. Company will start build-up for production of "new-type" aircraft, requiring about 2,500 persons by late 1948.

• Profitable nine months. . .**Northrop Aircraft, Inc.,** reported a profit after taxes of $304,050 for first 9 months of current fiscal year. Third quarter profit was largest of any period of fiscal year to date, Northrop reports.

• International trophy race at the National Air Races this fall will be sponsored by **Tinnerman Products, Inc.,** with five places reserved for non-American entries. Prizes for the race, which is for reciprocating engine class with less than 2,850 cu.in. cylinder displacement, total $7,500.

• U.A.L. cargo ton mileage up. . .An estimated 2,020,488 cargo ton-miles were flown by **United Air Lines** in April, up 58 per cent over the same month last year. . .U.A.L. is using television in its advertising program in Chicago and Los Angeles. One-minute spot films of scenes along the transcontinental route of its DC-6's are being shown in what may be the first use of video in air-line advertising.

• Entire **Wright Aeronautical Corporation** plant in Wood-Ridge., N.J., was closed between July 16 and August 2 for the company's annual vacation period.

Silicone News

DC SILICONES

DC 44 Silicone Grease for reliable permanent lubrication

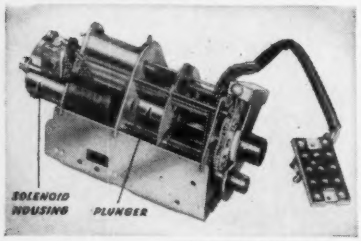

PHOTO COURTESY MOTOROLA INC.

DC 44 Silicone Grease permanently lubricates the plunger-solenoid contact surfaces in this Motorola Auto Radio push-button tuner.

Actual performance is the only true measure of a lubricant's quality. That is why more and more manufacturers are specifying Dow Corning Silicone Greases for their lubrication problems. Their tests show that longer lubrication life, greater oxidation resistance, elimination of gumming, and indifference to temperature extremes are all characteristic of the silicone greases.

Motorola Inc. of Chicago had a lubrication problem in their auto radio push-button tuner. The tuning is accomplished by a solenoid and plunger with a dash-pot action between the two for smoother operation. A thin film of the lubricant selected had to be permanent and maintain its consistency over the operating temperature range from −20° to 160°F. to give the dash-pot action.

Their engineers tested many lubricants but the only one to allow satisfactory operation and still lubricate after 75,000 cycles was DC 44 Silicone Grease. It maintains the right consistency to give smooth action and permanent lubrication. Even in thin films this silicone grease does not run out or form gum.

We recommend DC 44 Silicone Grease for permanently lubricated anti-friction bearings, and for high temperature applications up to 350°F. DC 41 Silicone Grease is recommended for temperatures up to 450°F. DC 33 Silicone Grease is both a low and a high temperature grease and is recommended for use from −95° to 300°F.

If you want permanent lubrication or have high temperature or low temperature problems it will pay you to investigate Dow Corning Silicone lubricants. Write for data sheet S 7-5 or call our nearest sales office.

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Dow Corning
FIRST IN SILICONES

Meet Your Section Chairman

Los Angeles Section

Willis M. Hawkins, Jr.

Beginning his professional career at Grumman Aircraft Engineering Corporation at Bethpage, Long Island, N.Y., in 1935 as a mechanic in final assembly, Willis M. Hawkins, Jr., is now Chief Preliminary Design Engineer at Lockheed Aircraft, Factory "A", Burbank, Calif.

Described as an outstanding designer and diligent worker with considerable technical proficiency in his specialty, Mr. Hawkins has been with Lockheed since 1937.

▶ **I.A.S. Branch Chairman**—Born in Kansas City, Mo., in 1913, he attended Illinois College at Jacksonville, Ill., 2 years before entering the University of Michigan.

At Michigan Mr. Hawkins was elected 1937 Chairman of the University Student Branch of the Institute of the Aeronautical Sciences. He was graduated the same year with a B.S. in Aeronautical Engineering. He was a member of the University of Michigan Glider Club and the Tau Beta Pi Fraternity. Now living in North Hollywood, Calif., he is married and has two children.

At Lockheed, he started in Structural Design as Layout Engineer, working in the Wing and Center Section, Electrical Section and Checking Department.

In 1939 he was assigned to Aerodynamic Research in Design Section as Supervisor of Wind Tunnel Testing and in 1941 was named Chief Preliminary Design Engineer.

▶ **S.A.E. Paper**—At a Society of Automotive Engineers meeting in 1945, Mr. Hawkins delivered a paper on "Problems in the Design of a Small Transport" and has given lectures on the jet engine and jet aircraft design before various educational organizations and institutions.

An active pilot and owner of a plane, he is Chairman of the Professional Race Pilots Association Technical Committee to approve designs for 190-cu.in. Goodyear Trophy Race planes.

Hagerstown Section

Roy W. Lessard

Roy W. Lessard, 33-year old Chairman of the I.A.S. Hagerstown Section, was born in Keewatin, Minn., March 14, 1915. Attending school in Buhl, he entered the University of Minnesota in 1934. Active in sports and music and elected to membership in Tau Beta Pi and Theta Tau Engineering fraternities, he was graduated from the university with the degree of Bachelor of Aeronautical Engineering with distinction in 1936.

▶ **Started at Lockheed**—His first year following graduation was spent at Lockheed Aircraft Corporation as a draftsman, empennage detail. The next year he became Layout Draftsman, Electrical Group, at Consolidated Aircraft Company, San Diego, where he remained until 1938.

Acting in the reverse of Horace Greeley's advice to young men, Mr. Lessard moved east, joining the Curtiss-Wright Corporation, St. Louis plant, as Stress Analyst, working as fuselage, controls, landing gear, and empennage stress group leader.

He was with Curtiss 2 years, then was drawn back to California to the Vultee Aircraft Corporation as Landing Gear Structures Engineer in 1941.

▶ **Returns to St. Louis**—However, the eastward pull brought him back to Curtiss-Wright's St. Louis plant in 1942 in the capacity of Project Structural Engineer. During the war, Mr. Lessard also was associated with Washington University as an instructor in teaching a war training structures course.

When Curtiss-Wright terminated its St. Louis plant in 1945, he accepted his present position as Chief Structural Engineer at Fairchild Engine & Airplane Corporation's Aircraft Division.

I. A. S. Sections

Boston Section

W. G. Cornell, *Secretary*

Preceded by an informal dinner attended by officers, speaker, and several members, the Section meeting April 28 had as its guest Hans Kraft, Aerodynamicist, General Electric Company, who spoke on "Subsonic Compressibility Effects in Aerodynamics."

▶ **Physical Interpretations** — Mr. Kraft's discussion was so arranged that the physical interpretations of the subject material were given throughout the talk, while the mathematical formulation of the physics was presented briefly as the final topic.

The speaker began with a discussion of aerodynamic problems in steam turbines. Extent of the effects of compressibility on these were next considered.

▶ **Specific Problem Detailed**—The specific problem of the compressibility flow design of turbine blading was detailed, and the work of Kraft and Dibble (JOURNAL OF THE AERONAUTICAL SCIENCES, October, 1944) in designing passage turns for transonic compressible flow was described.

Current investigations of Mr. Kraft on design of turbine blade shapes for subsonic compressible flow also were discussed.

Final topic—the mathematical basis of compressible flow theory—concluded the lecture. Chairman R. von Mises presided.

Detroit Section

Lawrence M. Patrick, *Secretary*

Members of the Section elected new officers at the May 21 meeting as follows: Chairman, Robert Dale; Vice-Chairman, Lawrence M. Patrick; Secretary, Henry Kerr; Treasurer, F. A. Hiersch.

New Councilors are: David M. Borden; Gordon C. Page; Rudolph Soellner; John C. Squiers (1944–1945 Chairman); Arthur A. Locke (1945–1946 Chairman); T. N. Kelly (1946–1947 Chairman); and Wilbur C. Nelson (1947–1948 Chairman).

George H. Tweney was appointed Area Councilor.

San Diego Section

Ralph H. Shick,
Corresponding Secretary

Approximately 200 members and guests heard an interesting talk on the flight testing of the XFJ-1 at the May 13 meeting. The meeting, which included a dinner, was held at the Officers Club of the U.S. Marine Corps Recruit Depot.

▶ **Hair-Raising Experiences** — The speaker, Al Conover, Project Test Pilot, North American Aviation, Inc., related some of his hair-raising experiences in some of the high Mach Number tests. He also presented a technicolor motion picture showing flight pictures of the XB-45, XFJ-1, and XP-86, as well as actual carrier take-offs and landings of the XFJ-1.

Seattle Section

Vaughn Blumenthal, *Secretary*

At the June 9 annual dinner meeting, Jere Farrah, Chairman, introduced James L. Straight, Manager, I.A.S. Western Region, and William Allen, President, Boeing Airplane Company.

Mr. Allen in turn introduced John K. Northrop, I.A.S. President, who spoke briefly of Institute plans for the Western Region before beginning his paper, "Development of All-Wing Aircraft."

▶ **222 Present**—With 222 members present at the Section's dinner meeting, Mr. Northrop presented a modernized version of the paper he delivered before the Royal Aeronautical Society in London last year on the development of all-wing aircraft.

Flight data, resulting from recent tests of the YB-49 jet model, were given, along with the projected plans for versions of the XB-35.

Washington Section

M. B. Ames, Jr., *Secretary*

Dr. Leon Beskin, Design Research Branch, Bureau of Aeronautics, Navy Department, was the speaker at the Section's May 12 meeting at which 59 members were present. Secretary M. B. Ames, Jr., presided.

(**Editor's Note:** Dr. Beskin's death was announced by the Navy Department in July.)

In addition to Dr. Beskin's talk, a film, *Development and Record Flight of Douglas D-558* was shown.

▶ **Nonmathematical Treatment**—Speaking on the subject of "A Nonmathematical Treatment of Three-Dimensional Airfoils at Supersonic Speeds," Dr. Beskin's paper covered rather completely the present status of supersonic wing theory.

MERCATOR PROJECTION

Unusual teaming of jet engines to powerful reciprocating power plants is pointed up in this striking flight view of The Glenn L. Martin Company's P4M-1 Mercator, Navy's latest land-based patrol plane. Two 3,250-hp. P. & W. Wasp Major engines are mounted in same nacelles with two Allison J-33 jet engines. The jets give 4,000-lb. thrust each for quick bursts of speed and extra take-off acceleration. The 40-ton aircraft has over a 3,000-mile cruising range and is equipped with latest radar, radio, and other electronic systems for reconnaissance work.

Add the Boeing B-50 to the growing list of modern aircraft that are capitalizing on the lighter weight, stronger construction and accurate pre-testing of FEATHER-WEIGHT oil coolers.

These modern FEATHER-WEIGHTS get their minimum weight and maximum resistance to extremes of temperature, vibration and shear from patented aluminum-alloy brazing of their thin all-aluminum sections.

How FEATHER-WEIGHTS will perform under actual flying conditions is clearly forecasted by critical tests in Clifford's wind tunnel laboratory, the largest, most modern in the aeronautical heat exchanger industry.

Inquiries concerning FEATHER-WEIGHT all-aluminum oil coolers are invited.

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Boeing B-50

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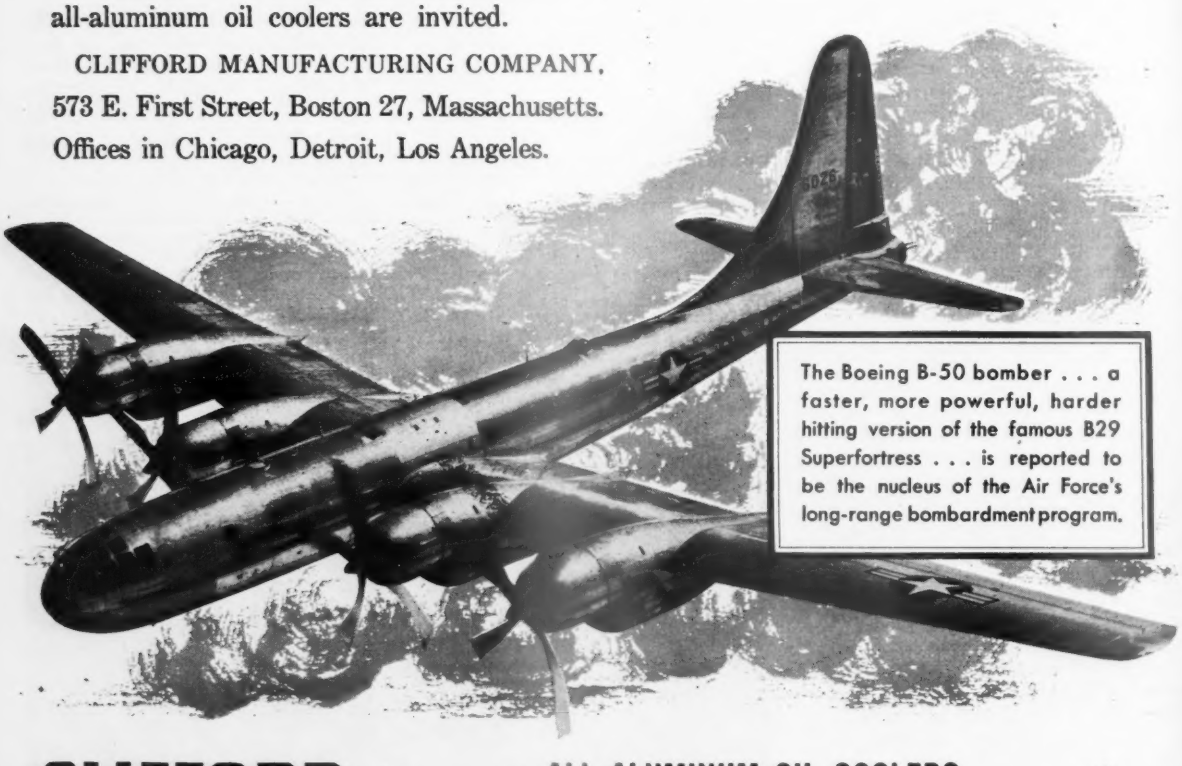


The Boeing B-50 bomber . . . a faster, more powerful, harder hitting version of the famous B29 Superfortress . . . is reported to be the nucleus of the Air Force's long-range bombardment program.

CLIFFORD

ALL-ALUMINUM OIL COOLERS

HYDRAULICALLY-FORMED BELLOWS

NEW CONVERTS TO AIR TRANSPORTATION

Thirty-four of the Institute's New York office personnel, many of whom had never made an airplane flight, flew in American Airlines' new Convair-Liner 240 late last June at the invitation of Bill Littlewood, American's Vice-President—Engineering. Piloted by Captain Boyd, the 240 circled the New York and north Jersey area, passing over the city's new airport at Idlewild, recently opened, and landing 45 min. after take-off from La Guardia at 9:15 a.m. Coffee and sweet rolls were served by American Airlines' hostess, Miss Cole. Result of the trip: new additions to the ranks of air-travel enthusiasts.

Student Branches

Aeronautical University

New officers were elected at the May 10 meeting as follows: Chairman, A. C. McDermott; Vice-Chairman, D. L. Morgan; Secretary, W. R. Wood; Treasurer, A. J. Foray. W. F. Lubach was elected Sergeant-at-Arms. In addition, C. G. Sheker and G. W. Schwandt were elected Honorary Chairmen.

Cal-Aero Technical Institute

Rockets was the principal subject of the May 11 meeting attended by 109 members. Chairman Robert J. Cameron presided.

Following a brief talk by C. T. Reid, Assistant to the school President, the guest speaker, George James, President, Reaction Research Society of Glendale, Calif., spoke on the "History, Present Use, and Future of Rockets." The talk was highlighted by some exceptional colored motion pictures on rocket launching in some recent desert tests by the society.

Opening with the history of rocket manufacture and warfare use, which dated back to the tenth or eleventh century when rockets were used by the Chinese, Mr. James traced rocket development down to present designs yet to be tested. Peacetime, as well as military, uses of rockets were pointed out.

Different types of rockets and propellants and their relative advantages and disadvantages were discussed, along with rocket engines.

In conclusion, Mr. James spoke of the society's present and future activities, inviting all such students interested in the work to join the organization and participate in its research activities.

Vice-Chairman John Fonda presided at the June 8 meeting at which the chief speaker was Dr. Walter LaVerne Howland, who is in charge of flight test instrumentation at Lockheed Aircraft Corporation.

Dr. Howland spoke on "Flight Test Procedure," beginning with a discussion of the cost of flight tests from the standpoint of equipment, insurance rates, and C.A.A. type certification tests. He also gave a close description of flight test plan and possible hazards to be encountered.

Cornell University

New officers were elected at the May 20 meeting as follows: Chairman, F. K. Moore, Vice-Chairman, Lawrence Fogarty; Secretary, Miss Jean McDonald.

University of Detroit

At the May 7 meeting, with Russel J. Cornair, Chairman, presiding, the following officers for the coming season were elected: Chairman, Robert W. Scheller; Vice-Chairman, John F. Rice; Secretary (Section A), John R. Lees; Secretary (Section B), James L. Freeh; Treasurer, William A. Konersman.

Following the election, M. Sanchez, Chairman of the I.A.S. Award Dinner, outlined plans for the annual banquet.

University of Florida

Election of officers for the fall semester took place at the May 11 meeting. Officers elected were: Chairman, William Petynia; Vice-Chairman, Ed Moilanen; Recording Secretary, Norman Singletary; Corresponding Secretary, Richard Arbic; Treasurer, R. Chianese.

After the election, a color film on the development of the McDonnell Phantom, Navy jet-propelled fighter, was shown.

Georgia Institute of Technology

With Chairman Edward Novotny presiding at the May 13 meeting, new officers were elected for the coming semester as follows: Chairman, Frank S. Barrett; Vice-Chairman, John Van Dyke Wilmerding; Secretary, Carl F. Branson; Treasurer, Henry W. Westbrook.

Illinois Institute of Technology

Election of officers at the May 13 meeting resulted as follows: Chairman, Clifford Douglas Seidler; Vice-Chairman, Paul K. Margolis; Secretary-Treasurer, Melvin G. Schneider.

The new officers took over their administrative duties immediately, planning the fall program.

University of Illinois

At the last meeting of the semester, May 19, Prof. H. S. Stillwell, Aeronautical Engineering Department head, discussed job opportunities and interviews.

New officers elected: Chairman, Vernon F. Van Heyningen; Vice-Chairman, William A. Brooks; Secretary-Treasurer, Lowell K. Masley.

Term of office of new officers begins with the fall semester. Edward J. Brisick presided.

Massachusetts Institute of Technology

R. M. Jackson, Supervisor, Project Control Unit, New York Engineering Office, American Airlines, principal speaker at the May 13 meeting, gave a talk on "Airline Transportation, Present and Future." His speech covered all aspects of air-line transportation.

The size of the aircraft in use was shown to have a direct bearing on the economic operation of an air line. Present-day plans, according to Mr. Jackson, call for transports not greatly exceeding the DC-6 in size.

Air freight also was covered in the talk, in which the design of a cargo plane was described. Lewis Roosa, Chairman of the Student Branch, presided.

University of Minnesota

A business meeting was held May 26 at which new officers were elected for the 1948–1949 season. Results were as follows: Chairman, Dave Benepe; Vice-Chairman, Edward Saloum; Secretary, Alfred Ross; Treasurer, Dave Burtt; Publicity Chairman, Casimir Frozina.

Following the election, Ben Cecil of Minneapolis-Honeywell Research Department gave a talk on "Automatic Controls."

Northrop Aeronautical Institute

First formal meeting of this new Branch was held June 7. Guests included Dr. Milton U. Clauser, Douglas Aircraft (El Segundo), who was the principal speaker; John K. Northrop, President of I.A.S.; and James L. Straight, Manager, Western Region of the Institute.

Student Chairman E. M. Prouty presided.

Dr. Clauser, who presented a paper on "Installation and Preliminary Design Problems of Jet Engines," first gave a brief discussion of the true value of the designer and his part in the overall scheme of the engineering of an airplane. "The designer," he explained, "is the hub around which the requirements of the many theoretical specialists are focused," adding that "the designer transfers theory into reality; without him there would be no airplane."

University of Notre Dame

The Branch held its Spring Banquet May 13 at the Oldenburg Inn, south of the City of South Bend. Approximately 80 members and guests were present at the gathering, described by Prof. N. M. Brown, Head of the Department of Aeronautical Engineering, as "the most successful and entertaining social function ever held by the Notre Dame I.A.S."

A talk on the evils of Communism was given by the first speaker of the evening, the Reverend Cornelius J. Laskowski, CSC, of the Department of of Modern Languages, and Chaplain of the Fire Department.

Professional opportunities in the aviation industry were described by J. Allan MacLean, Chief Engineer, Bendix Landing Gear and Brake Division, and former Instructor of Aeronautical Engineering at Notre Dame.

Guest of honor William T. Piper, President of Piper Aircraft Corporation, in a colorful talk depicted the future of the personal aircraft industry in a not too favorable light.

He summarized his views by pointing out the following facts: (1) American youth has an intense desire to fly but is not in a position, financially, to purchase aircraft and thus stimulate the industry; (2) the elders, who are in a financial position to buy, lack as a class the inherent desire to fly; (3) small aircraft lack the utility that could make them a popular mode of travel; (4) the average personal plane is unprofitable to its owner unless the owner has need to travel greater distances than are usually traversed in an automobile; (5) the average American does not travel often enough or far enough to create a large market for this type of aircraft.

Walter M. Marut, Branch Chairman, was toastmaster. Banquet arrangements were the responsibility of Rudolph H. Kempter and Thomas J. Neff. Vice-Chairman John P. Hoey assisted the Chairman in banquet decorum, while Ernest J. Tursich directed the publicity. William A. Alden handled the distribution and sales of bids.

At the May 20 meeting, Chairman Marut described the semester as the most successful since reorganization of the local chapter in 1946. Membership of the branch constitutes approximately 80 per cent of the total enrollment of students in the Department of Aeronautics. A drive in September will strive for 100 per cent enrollment, he said.

Final reports on various Branch activities were given including those of Vice-Chairman Jack Hoey on the bowling team, which finished among the first ten in its league; Ernest Tursich, Editor of the *Burble*, who described accomplishments and future plans; and the Secretary-Treasurer, David Medwid, who presented the semiannual financial report, which was accepted.

A film by the Air Force, *G and You*, concluded the meeting.

Oregon State College

A film by the Air Force, *Learn and Live*, and two talks by student members, Ray McPherson and Tom Deschner, were given at the May 5 meeting.

The talk by Ray McPherson stressed the hazards of private flying and what the engineer can do to design safer aircraft. Private flying, he said, is 25 times more dangerous than driving a car.

The design engineer, McPherson said, can eliminate some of the factors that cause death or injury in aircraft. Among the points made by the speaker were that oval cross-section tubing can be used in the cockpit to prevent inward buckling of the structure, and that the instrument panel can be designed so as to absorb part of the force of a crash. In addition, the control wheel could be designed with a larger surface area, and safety belts should be designed to withstand great forces, McPherson said.

Tom Deschner described the problems confronting the owner of a personal plane. His talk was principally about the Culver V, in which type he averaged 600 to 700 hours per year flying time.

In a trip made by Deschner from Los Angeles to Troutdale last summer, he recorded the following data:

McCormick–Modesto		
	338 miles	3.5 hours
Modesto–Eureka		
	289 miles	3.0 hours
Eureka–Troutdale		
	406 miles	4.0 hours
Total,	1,033 miles	10.5 hours
Total cost		$20.47
Average speed		101 m.p.h.
Fuel, gal. per hour		5.81
Oil, quarts per hour		0.23
Cost per mile		$1.88 (gas and oil)
Cost per hour		$1.92
Miles per gal.		16.2

Conditions of the airports were, he said, inadequate on the whole. Mechanics are underpaid and are responsible for any negligence, Deschner added, and he believes that private flying for anyone but the sportsman will end unless the C.P.T. is again undertaken by the Government.

Parks College of Aeronautical Technology

At the May 12 meeting the Chairman, Richard A. Dean welcomed new members. Two films, *Static Testing* and *Production Methods*, were shown.

Spartan College of Aeronautical Engineering

Plans for the graduation banquet were discussed at the May 27 meeting

with the Chairman, Gene Hess, presiding.

Tri-State College

At the fourth meeting of the spring term on May 12, the film, *PBM-3 Wing Destruction Test* was shown. Chairman David J. Russell presided.

Vice-Chairman R. A. Laurito reported that the characteristics of the barrel-type wing without engine or propeller had been obtained in the wind tunnel. H. L. Roland told of the results obtained from tests made on the airfoil to be used on the V-tail project. The V-tail was to be tested next, he said.

News of Members

Rudolph Anger, formerly Aircraft Factory Inspector, 4th Region, C.A.A., has been transferred to the Authority's 7th Region, Manufacturing Inspection Division.

Maurice B. Bernhard resigned as Engineering Test Pilot, Atlantic Airlines, to take the post of Flight Test Engineering Inspector with the C.A.A.

V. Cadambe is Assistant Director to Head of the Department of Applied Mechanics and Materials, National Physical Laboratory of India. He resigned as Technical Officer, Tata Aircraft Ltd., India.

John M. Coan, Jr., received the degree of Doctor of Aeronautical Engineering at Polytechnic Institute of Brooklyn in June.

John Thornton Deden is with McDonnell Aircraft Corporation as Design Engineer.

Thomas S. Feaster has been named Stress Analyst, Fairchild Engine & Airplane Corporation. He had been Senior Detailer, McDonnell Aircraft.

Hugh E. Gardenier, former Research Analyst at Consolidated Vultee Aircraft, has joined Sverdrup & Parcel, consulting engineers, as Junior Aerodynamicist.

Norman F. Grant, A.A.F. pilot, is a Graduate Student at Rensselaer Polytechnic Institute.

Burt J. Hall is in the aircraft equipment business for himself. He was Senior Liaison Engineer with The Glenn L. Martin Company.

Josef Stanislav Jan Hlobil, former President of Columbia Aircraft Industries, is Manager, Universal Cargo Aircraft System.

Claude Horton is President and Manager, Repair & Sales Depot, Inc. He had been Field Engineer, Huck Manufacturing Company.

John K. Hulbert who resigned as Chief of the Special Development Unit, Wind Tunnel Branch, Wright Field, is now Project Supervisor—Supersonic Laboratory, Ohio State University.

Floyd G. Keiter is Structural Engineer, P-2, U.S. Department of Interior, Bureau of Reclamation, Denver Federal Center, Denver, Colo. He had been with McDonnell Aircraft as Senior Stress Analyst.

Douglas A. King has been named Aeronautical Research Scientist, Langley Tank No. 2, Langley Memorial Aeronautical Laboratory, N.A.C.A. He was Aeronautical Engineer, P-3, Tank No. 2.

Vahey S. Kupelian is Manager of Research & Development, H. A. Kuljian & Co., consulting engineers.

Rene Lucien is President—Technical Director, Messier (Paris). He was elected a Fellow of the Royal Aeronautical Society at the Society's last annual meeting and was appointed a member of the Comité technique et industriel des fabrications aeronautiques (Technical and Industrial Committee for Aircraft Manufacturing) at the proposal of the French Air Minister.

Cameron N. Lusty is Assistant Chief Engineer, Globe Corporation, Aircraft Division, having been promoted from Development Engineer. He has been in charge of preliminary and development design of pilotless aircraft targets and proposal designs for various propeller-driven and jet-powered, parachute retrieved target P/A.

Cletus Peter Schaff has been transferred to Baltimore as Special Assistant to the Bureau of Aeronautics, Navy Department. He had been BuAer's Representative at Fairchild Aircraft.

Richard A. Schram, former Navy Lieutenant, is Chief, Non-Flight Personnel & Agencies Division, Airman Branch, C.A.A.

Sales Manager: *Romus Soucek has been appointed Sales Manager of the Westinghouse Aviation Gas Turbine Division at South Philadelphia, Pa. A native of Medford, Okla., Mr. Soucek has devoted all his professional life to aviation. He came to Westinghouse in 1946 from Consolidated Vultee Aircraft where he held engineering and development posts for 5 years, particularly in the field of aircraft power plants. Previously he had been with Wright Aeronautical in Paterson and in California.*

Donald W. Smith is Chief Engineer, Instrument Division, and Supervisor of Research & Development Laboratory, Kearfott Company, Inc.

James L. Snyder has been appointed Senior Detailer, McDonnell Aircraft Corporation.

Alexandros M. Voutsas is Engineer in the Aerodynamic & Heat Transfer Department, General Electric Company. He was Aerodynamicist "B" at Consolidated Vultee Aircraft Corporation.

James Steven Voymas, former Power Plant Engineer with Consolidated Vultee Aircraft, is now Plant Engineer, Hood Rubber Company.

Charles H. Wagner is in the Engineering Department, Curtiss-Wright Corporation (Columbus). He had been a student at Academy of Aeronautics.

Members Elected

The following applicants for membership or applicants for change of previous grades have been admitted since the publication of the list in the last issue of the REVIEW.

Elected to Associate Fellow Grade

Fortune, William Charles, S.M. in Ae.E., Comdr., Ch. Engr., Naval Aircraft Factory, N.A.M.C., U.S. Navy (Philadelphia).

Jacovleff, Dimitry, Prof. (Ordinaire), Universities of Liege & Ghent (Belgium).

Reed, Warren D., M.E., Chief Project Engineer, Hughes Aircraft Co.

Shenstone, Beverley Strahan, M.A.Sc., F.R.Ae.S., Chief Engineer, British European Airways (England).

Smith, Paul A., B.S.E., U.S. Rep. to Council of International Civil Aviation Organization, Dept. of State (Canada).

Transferred to Associate Fellow Grade

Ames, Milton Benjamin, Jr., B.S. in Ae.E., Aero. Research Scientist & Head, Aerodynamics Research Br., Washington Office, N.A.C.A.

Porter, L. Morgan, M.E., Design Project Engineer, in Charge of Analytical Design Group, Pratt & Whitney Aircraft Div., United Aircraft Corp.

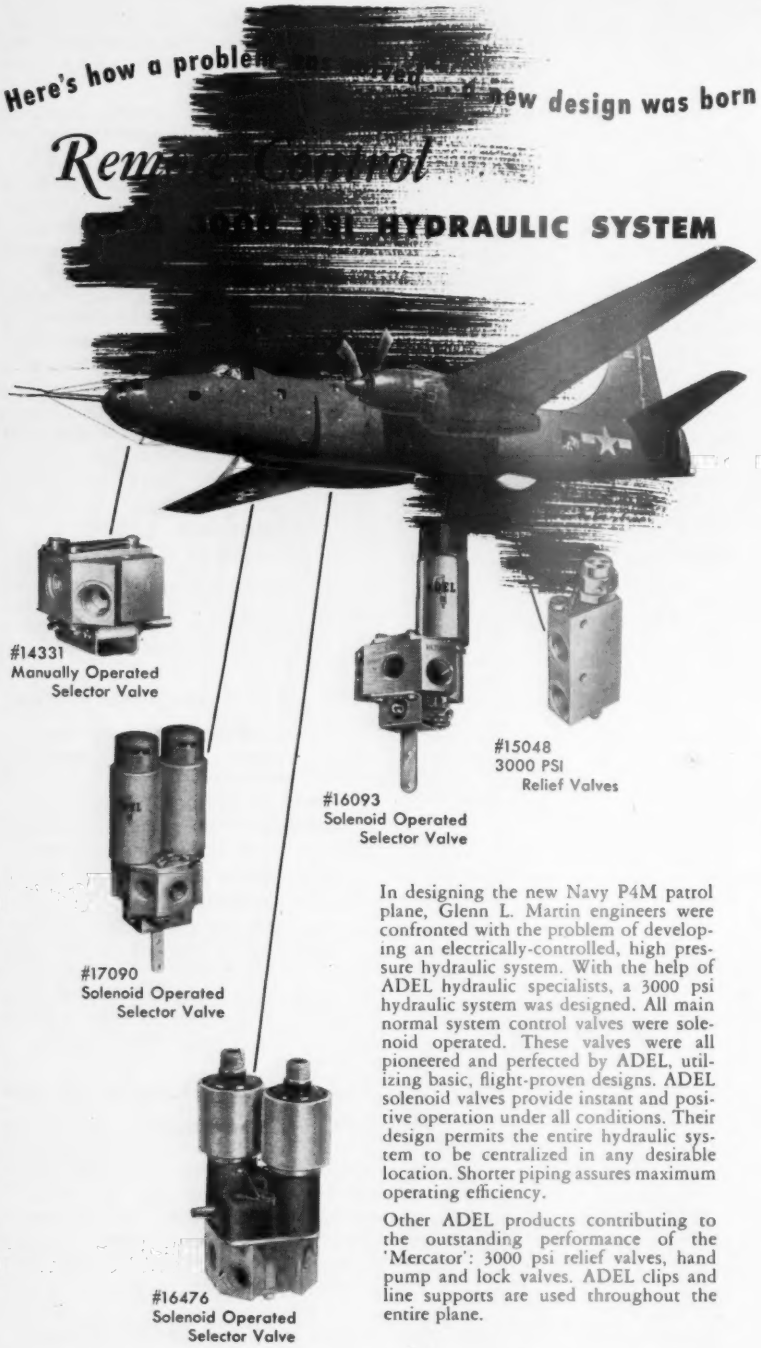
Elected to MEMBER Grade

Blumenthal, Vaughn L., B.S. (Chem.), Aerodynamics Engineer "A," Boeing Airplane Co.

Clayton, Harry H., B.S. in M.E., Aero. Engineer P-6, Flight Test Engr., Tech. Engrg. Div., Muroc Base, U.S.A.F.

Clexton, Edward William, M.S., Capt., Review Officer, Aeronautics & Research Budgets, Office of the Secretary of the Navy, U.S. Navy.

Coleman, Howard S., Ph.D., Assoc. Prof. of Physics & Research Physicist, Defense Research Lab., University of Texas.



In designing the new Navy P4M patrol plane, Glenn L. Martin engineers were confronted with the problem of developing an electrically-controlled, high pressure hydraulic system. With the help of ADEL hydraulic specialists, a 3000 psi hydraulic system was designed. All main normal system control valves were solenoid operated. These valves were all pioneered and perfected by ADEL, utilizing basic, flight-proven designs. ADEL solenoid valves provide instant and positive operation under all conditions. Their design permits the entire hydraulic system to be centralized in any desirable location. Shorter piping assures maximum operating efficiency.

Other ADEL products contributing to the outstanding performance of the 'Mercator': 3000 psi relief valves, hand pump and lock valves. ADEL clips and line supports are used throughout the entire plane.

Another example of ADEL'S contribution to progress in the aviation industry.

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Ebert, John W., Jr., B.S., Aero. Research Coordinating Engineer, Langley Mem. Aero. Lab., N.A.C.A.

Fawkes, Emerson Evans, S.M. in Ae.E., Comdr., Chief Project Engineer, Flight Test Div., N.A.T.C., U.S. Navy.

Gavin, Joseph G., Jr., S.M. in Ae.E., Aero. Engineer, Preliminary Design Section, Grumman Aircraft Engineering Corp.

Gravalos, Fausto G., Ph.D., Asst. Prof. of Aero. Engineering, Rensselaer Polytechnic Institute.

Halen, Raymond F., B.A., Asst. Staff Engineer—Power Plant, Republic Aviation Corp.

Heldenfels, Richard R., B.S., Aero. Engineer, Structural Research, Langley Mem. Aero. Lab., N.A.C.A.

Hyland, John Joseph, B.S., Comdr., Asst. Dir., Flight Test Div., N.A.T.C., U.S. Navy.

Johnson, Charles Revere, B.S., Sr. Engineer, Shell Oil Co., Inc.

Kelland, Herbert Harold, B.A.Sc. in M.E., Asst. Research Engineer, Div. of Mech. Engineering, Flight Research Section, National Research Council (Canada).

Kelsey, Benjamin S., M.S. in Ae.E., Col. Chief Control Group, Office Deputy, Chief of Staff Materiel Hq., U.S.A.F.

Kohl, Robert Clement, B.S. in M.E., Aero. Research Scientist, Flight Propulsion Research Lab., N.A.C.A.

Lang, Robert J., B.S., Chief Engineer, Aero Industries Technical Institute.

Liddell, George J., M.E., Development Engineer, Sun Oil Co.

Marshall, John, LL.B., V.P., Luttrell & Senior, Inc.

Myers, John W., LL.B., V.P., Northrop Aircraft, Inc.

Rethman, Vincent Carl, M.S., Major, Research & Development Engineer, A.M.C., Wright-Patterson Air Force Base, U.S.A.F.

Ries, Rudy Franz, Dipl. Ing., Asst. Chief Engineer, Edo Corp.

Sefeldt, Nils Olof, Chief Wing Engineer, Swedish Royal Air Force.

Smith, Donald Winthrop, Chief Engineer, Instrument Div., Supervisor of Research & Development Lab., Kearfott Co., Inc.

Smolin, Howard Lee, M.S., Lt. Comdr., Experimental Engineering Officer, U.S. Navy.

Stoffer, Charles T., Lt. Col., Air Inspector, Flight Service, Hq. Air Transport Command, U.S.A.F. (Washington, D.C.).

Tetley, Wilfred Henry, M.S. in Ae.E., Asst. Dir., The Cambridge Field Station, U.S.A.F.

(*Continued on page 84*)

The CASE of AIRLINE Z

Martin 2-0-2 Flies Its Route 25% Faster than Prewar Plane!

HERE ARE THE FIGURES!

FLIGHTS	Using Martin 2-0-2	Using Standard Prewar Plane
Boston to New York	45 min.	85 min.
New York to Philadelphia	37 min.	44 min.
Philadelphia to Baltimore	30 min.	40 min.
Baltimore to Washington, D. C.	20 min.	24 min.
Washington, D. C. to Elkins, West Va.	50 min.	74 min.
Elkins, West Va. to Parkersburg, West Va.	31 min.	43 min.
Parkersburg, West Va., to Cincinnati	51 min.	77 min.
Cincinnati to Indianapolis	40 min.	49 min.
Indianapolis to Chicago	52 min.	68 min.

*Did you miss "The Case of Airline X" or "The Case of Airline Y"? We'll be happy to send you copies.

MINUTES count when you're flying short-hop routes, because they're the places where profits leak away. That's why the Martin 2-0-2's time-gaining speed and much greater payload capacity are great news for airlines! This modern airliner offers high-speed luxury service to shorten schedules, attract more passengers and generate more traffic in cities with airports too small for most other airliners. The 2-0-2 can serve these smaller airports because it is CAA-approved to take off and land with maximum load in the shortest distance of any postwar airliner. It carries 36 passengers to the standard prewar twin-engine plane's 21. And its simplified loading, unloading and servicing means shorter stops between hops.

Airline Z is a typical example! Based on actual performance figures, a Martin 2-0-2, being 50% faster than pre-war planes, on this hypothetical route would save almost 2½ hours between Boston and Chicago. That is a minimum saving of 25% in route time. Thus, the 2-0-2 would be landing in Chicago while the prewar plane was only halfway between Parkersburg, West Va., and Cincinnati, Ohio. And these figures assume the *same* ground time for both planes. *Actually,* the Martin 2-0-2 would save still more time because it requires less time on the ground between landing and taking off! Just additional velvet on the 2-0-2.

Here's one more example of why the Martin 2-0-2 . . . *the world's top twin-engine* airliner . . . is the plane to put airlines *in the black!* For full details, write today to: The Glenn L. Martin Company, Baltimore 3, Maryland.

Martin
AIRCRAFT

Builders of Dependable *Aircraft Since 1909*

A Guest Editorial

"ZERO TO 200"

The first I.A.S. "Meeting on Wings" proved to be a great success. For those who participated and for those who listened it was an effort worth while. It was by all odds our biggest and best Personal Aircraft Meeting. The total attendance for the three cities—Detroit, Wichita, and Dayton—was nearly 600. The following pages comprise a report of four highlights. Your editors have selected the most pertinent parts of the presentation of the three meetings and have combined them into a composite report. As a starter, some quotes from the introductory remarks of Panel Chairman Loening appear here in lieu of the usual monthly editorial.

THE SUBJECT OF OUR SYMPOSIUM is "Can Further Development Extend Personal Aircraft Utility?" Let us make it clear at once that while we may be critical of many things that are characteristic of present-day aircraft, we are not being critical of the work that is now being done on them. We want, if possible, to extend the discussion into new realms without in any way overlooking the importance of the aviation development that you, as designers and builders, are now carrying on. We are fully aware that we must not overlook the fact that the present personal aircraft industry is a going concern and that we can't depart too much from its normal evolutionary processes without getting into serious financial trouble. We want simply to bring before you the possibilities of extending your horizons as a guide for the future.

* * * * *

The I.A.S. has tried in this particular symposium to do something really different—to bring technical discussions to those who are interested rather than to ask them to interrupt their busy lives to travel long distances to participate in a meeting. It is a new idea in technical work of this character for any engineering society...

* * * * *

When we come to the question of whether or not the airplane is really getting all that is coming to it, whether

the airplane business is getting all the markets that it can get, we realize that some parts of the country are in more advantageous positions than others. For example, people in the middle west are "sitting pretty" in the largest aviation center, geographically and topographically, that the world has to offer. Here the airplane is really on its home ground. Other parts of the country do not fare so well. Even in Florida, where the weather is good, private flying has not developed as it should for the simple reason that there isn't usefulness enough for planes in that area—there are not enough places to go, distances are not great enough. The New England region is bad, with hilly, wooded areas and few landing fields and a continuous series of weather difficulties of all kinds. We must all realize that present-day aircraft are not so well fitted for many of the regions of this country as they are for the middle west.

* * * * *

What we need for most sections of this country is a plane that will go from Zero to 200 m.p.h. I won't say "an airplane." I will say a "flying machine"—something different that will get us into the air and get us to our destination fast once we do get into the air. Unless we get that, the automobile will continue to steal a great deal of our thunder because of constant improvement in our highways and in the cars themselves.

So there is still something that can be done that may be helpful to you in greatly extending your markets. We should not limit our thinking to a market of 6,000 to 10,000 planes a year. No indeed! If we can get a flying machine that will actually land at zero miles and will travel in the air at 200 m.p.h., and will do so at a reasonable cost and with reasonable simplicity of control, we will have a market for 500,000 units a year! This is an exceedingly important thing for all of us to aim at and to hope to develop, because such a figure will provide the backbone for a really great air industry, one that will not be dependent on how Mr. Stalin feels tomorrow or the next day.

* * * * *

The I.A.S. is in hopes that, by presenting this meeting in this way, it can stimulate interest, particularly among young engineers—to have them realize that there is much left to do. The development of personal aircraft is by no means a solved problem. There is great room for original and new thinking along the lines of spectacularly new machines, new designs in convertible and in roadable planes that may have boundary-layer control, jet engine development providing induced airflow over wing—further adoption of high lift devices--and many other as yet untapped new design features to extend the usefulness of flying. We will not get anywhere very fast until we develop some of the new things more intensively.

—Grover Loening

Meeting on Wings

"Can Further Development Extend Personal Aircraft Utility?"

Excerpts from the Talks and Discussions at I.A.S. Personal Aircraft Meetings in Detroit, Wichita, and Dayton, June 7-11, 1948

EDITOR'S NOTE—*A recording and transcription of the entire proceedings of the three Personal Aircraft Meetings in Detroit, Wichita, and Dayton have been made. Space limitations in the* REVIEW *make it impossible to publish the full papers and discussions in the magazine. Only the most pertinent highlights of the four principal papers and discussions are included in the following excerpts. However, the full proceedings will be published in preprint form through the Sherman M. Fairchild Publication Fund if there is a sufficient demand for them.*

Anyone interested in obtaining copies of the entire proceedings of all three meetings should immediately notify the Preprint Department of the Institute. The proceedings will be published at cost; $2.50 to nonmembers and $1.25 to members.

ANALYSIS OF THE BUSINESS ASPECTS OF THE PERSONAL AIRCRAFT INDUSTRY

By

Arthur H. Tully, Jr.

Adviser on Personal Aircraft to the President's Air Policy Commission
Coauthor with Lynn L. Bollinger of the book "Personal Aircraft Business at Airports"

"ALMOST 2 YEARS AGO we (at Harvard Business School) started on a study of the personal flying airports, but it changed its direction very soon and we found we were not studying the airports; we were studying a business. The airport where personal flying was carried on was really the business site of the fixed-base operator.

"The fixed-base operators themselves asked us to study ways in which, by accounting methods and different methods of control, etc., they could improve their financial status and the smoothness of their operations. We soon decided that this was not a commission . . . to write an operations manual for them, but to try to study what might be right and what might be wrong with the business.

"The published results . . . were written with the purpose of helping to preserve as much of this declining business as possible as a system of distribution for the aircraft we are building today. In other words, we wanted to prolong the survival of as large a proportion of the 7,000 or 8,000 fixed-base operators as possible while we are waiting for the aircraft, without which . . . a large proportion of that number could not stay in business. . .

"Another highly important problem plaguing the fixed-base operator . . . was the peculiar relationship of a private business being carried on on publicly owned property... Neither was satisfied with that relationship.

Left to right, beginning opposite page: (1) Aboard Esso's Lockheed Lodestar, "Meeting on Wings" Panel relax between stopover points. (2) Grover Loening, Panel Chairman. (3) E. W. Robischon, Secretary of I.A.S. Dayton Section, greets principal speaker, Arthur H. Tully, Jr., upon arrival in Dayton. (4) "Meeting on Wings" group ready for take-off from New York included: Bennett H. Horchler, Executive Vice-President, I.A.S.; Robert R. Dexter, Secretary, I.A.S.; Grover Loening, Special Consultant to N.A.C.A. and Adviser to Secretary Forrestal; Jerome Lederer, President, Flight Safety Foundation; Wolfgang Langewiesche, Research Pilot, Kollsman Instrument Division, Square D Company; Arthur H. Tully, Jr., Adviser on Personal Aircraft to the President's Air Policy Commission, and Co-Author with Lynn L. Bollinger of the book, *Personal Aircraft Business at Airports;* Robert Bacon, Co-Pilot of Esso's Lodestar; and Robert C. Wormald, Assistant Manager, Aviation Division, Esso Standard Oil Company. Also included in the group, but not shown in this picture, were Fred E. Weick, Aeronautical Engineering Department, Agricultural and Mechanical College of Texas; Col. Don Provost, Chief Pilot for Esso; and Welman A. Shrader, Director of Publications, I.A.S.

The municipal officials, with the laudable objective of placing their airports on a self-supporting basis, were in many cases asking for, if not actually getting, rates that, from our views of the business, it simply would not support.

"We have gone rather extensively into that question of leases and the rates the business could bear and tried to work out logically why the municipal airport owner is really entitled to not more than, to them, the shockingly low figure of about 2 per cent of gross business...

"The early evidence that we gathered shows that although the personal aircraft business had had a tremendous postwar bulge, it really was a bubble that was bursting as we were in the field, and the decline was setting in, as the sales record shows. The sales record alone indicates that something is wrong, either with the way the business is being run or with the product that is being sold. We think—the conclusion to us is inescapable—that the basic trouble is not so much internal as it is in the product being sold.

"How can you expect to have a distributor organization where the business units in it actually sold about one of the basic product per operator? We know you can point out to us that in 1947 there was here and there an operator who perhaps sold 15 or 20 airplanes, but actually, when you take the rough figures—and I must emphasize that all the figures we could gather were pretty rough—of the number of operators in the business and the figures on sales, in 1947 there were about two airplanes sold per operator.

"However, from the evidence we can find in the field, half of those airplanes were sold to operators, so that actually the bona fide sale to the private owner, we believe, was about one airplane per operator in 1947. Now you can compare it with boats or automobiles or anything, but a sales organization that sells only one product per unit of business is not operating on a very big volume...

"What sales volume does this industry need? We don't propose to look into a crystal ball and then make comparisons with automobiles and boats, etc.; but we do think that just on an operator basis we can supply an approximate minimum figure worked out this way: Assume the present number of operators to be 8,000. About 6,000 of them are what we call diversified—that is, doing most phases of the fixed-base business rather than specialists, such as crop dusters, and so on.

"Assume a survival—and this we think is optimistic—of 4,000 out of that 8,000 once the G.I. program is out. Is 40,000 to 60,000 annual airplane sales, or 10 or 15 per operator, too high a guess as to what this business needs? We don't say categorically that that is the figure, but we think it is something resembling that.

Contrast that with 15,000 last year and less than 10,000 this year...

"We found rays of hope in two things. One was the gradual growth in what we choose to call the executive flying—that is, company-owned planes—and the flying farmer is the second. We found that the airplane in both those categories is having more utility than it does for those of us who live in relatively congested sections of the country.

"Utility is undoubtedly the answer—the most important answer. But another factor that enters into it importantly, we found, is still something that we are all familiar with and is not news—it is the question of safety...

"From the family point of view, the real or imagined lack of safety has led to a lack of utility. Most of us who are emotionally and otherwise interested in this business can immediately give figures and a good many arguments for talking those families out of their position, but do the figures support our argument? Unfortunately, they do not!...

"In an effort to study utility and the causative factors for better airplane ownership in some places than others, we did a lot of wrestling with ratios and the figures of ownership and tried to find some correlation. That is pretty difficult. The State of Nevada with 231 airplanes owned per 100,000 population was the highest in the country. We had Nevada in mind when we thought of all the other states.

"Nevada indicates the advantages of airplane ownership that other states haven't got. The national average is 58 per 100,000 population. Kansas has 132, high up on the list. Then we come to the northeast section of the country with fairly high purchasing power per capita, and we find Rhode Island with 23, Connecticut with 34, and New York with 33, forty-first in rank among the states in airplane ownership...

"We found there was some reverse correlation between airplane ownership and the sparsity of population. Where population was sparse and where the miles of surfaced roads were low, you had somewhat higher airplane ownership, but it was not an entirely clear correlation, one on which you could prove a case for the country as a whole.

"There was some correlation with buying power in a few states—that is, the states with low buying power, relatively, to the rest of the country (Alabama, Kentucky, and Mississippi are in the low brackets of airplane ownership). But conversely, the states with high purchasing power—consumer buying power—were not by and large in the high ownership category.

"Because of the weather, Texas and California were at first thought to be the promised lands of private flying. We were disillusioned when we visited those states. We found practically no direct correlation with flyable weather...

"We found the correlation in Arizona with the best weather and a high aircraft-owning state; but, on the other hand, not very far away, Kansas ranked, according to our effort at categorizing the wheater, thirty-first in weather and third in aircraft ownership per unit of population—just ahead of Arizona, which ranked fourth. Therefore, that avenue of analysis did not yield enough correlation to be really convincing.

"Then what is the real factor causing high airplane ownership where we found it? It is accessibility, utility through accessibility. In a part of the country where you have numerous small airports close to town and where an agricultural population wants and needs to go to town frequently on business and on pleasure, there we found high aircraft ownership...

"But then are we going to build a volume business in aircraft whatever the form—present fixed wing or otherwise—unless in the area where 75 per cent of the purchasing power of the country is now found (that is, east of the Mississippi) we are able to give the vehicle utility in that part of the country? We don't think that we are.

"Why don't they own airplanes in any such ratios in that part of the country, particularly the northeast and the Atlantic seaboard? Some of the negative factors are poorer-than-average weather, but I think that we certainly can, with new navigational aids, work that out if there is a volume demand for it... It may possibly be because the towns and cities are closer together and you really have less travel; lower mileage per person, possibly because of the competitive forms of transportation; more air-line and Pullman service, saving time and expense.

"But if you offer greater utility in the personal plane, we think that even those competitive factors can be at least partially overcome. We feel that we need an airplane that can safely and tolerably use small single-strip landing areas close to town, close to the city. By and large in the more congested areas, there isn't much real estate left. If there is, there is the tremendous cost to buy it and develop it into the superduper airports that we now have. We need one-way strips, using what we are hopeful is a permanent development, the castering landing gear.

"We need many of these close-in landing areas, close to town, so that you won't have the ground transportation problem. Many of these small and cheaper landing areas automatically increase the safety in flying. If it is a hop and a skip and a jump between many of these landing areas, aren't you thereby going to cut down the present adverse affect of weather? Aren't you going to increase your safety factor?...

"If the answer is yes—and we believe it is—what do we need in the new airplane?

"We need a quiet airplane. We need quiet propellers and quiet engines. We need an airplane that will minimize or eliminate hazards, real or *imagined*—and I underline imagined—to persons and property, an airplane that will take off and leave the field at a high angle of departure particularly...

"To use these strips, we need an airplane with almost the characteristics of the prewar Jenny that I remember in my home town used to use the ballpark. Where is the airplane today that can use the ballpark? It should

Meeting on Wings

Plant Visitations

Panel Members and local Section personnel are accorded hearty welcomes at the plants visited during the meeting. *Top left:* at Wayne, Mich., Ernest Wenigmann, Division Manager; B. J. Simons, Chief Division Engineer; and W. H. Klenke, Jr., Sales Manager; of Stinson, take the group on a personally conducted tour of the plant. *Top right:* Tom Salter, Vice-President and Chief Engineer, and Don Flower, Sales Manager, demonstrate the efficiency of both the Cessna plant and Cessna's airplanes to Panel Members. *Center left:* Esso's Lockheed Lodestar, the Panel's air lift for Meeting on Wings. *Center right:* Inspecting Boeing's Stratocruiser. *Bottom left:* Panel and local Section Members gathering for lunch at Boeing's Wichita plant. *Bottom right:* The group drops in at St. Louis for a visit to McDonnell Aircraft and a congenial luncheon with J. McDonnell.

A small segment of the distinguished guests who heard the Panel and joined in the discussion at the Dinner Meeting in Detroit.

have high lift, slow landing characteristics, capable of using small areas of high-cost, close-in urban land, one that will be tailored to the human being as he exists physically and psychologically—in short, easy to fly safely.

"The tolerance of communities for airports and for airplanes has not changed except for the worse, and you aren't going to change them until you change the product.

"We have much to say in our book about the regulatory environment, and we think, without placing any blame on anybody, that for world reasons we have geared our whole aviation picture to a military concept. Some of the results of that are strictly detailed red tape and regulation of the airplane itself that retard step-by-step improvements and add serious costs.

"But in the realm of flight training, aren't we still training military pilots in requiring spins? Spins with people in our best potential market—middle-aged men—discourage many prospective pilots in the very class we want to sell to, and yet our whole training and license requirement is geared to that Jenny concept of flying.

"In airport standards it is the same—geared to the long take-off. Even in the realms of C.A.A., which are not regulations, airport separation has been a doubtful quality. You add the classes of the airports together and you must have that many miles of separation. . .

"Are the cross-country airplanes—the Cessnas, the Stinsons, the Bellancas of the day—really any better than the 1923 Bellanca with a speed of 95 m.p.h.? Or the 1928 Cessna; 230 hp. and 150 m.p.h.? Or the 1928 Monocoup; 60 hp., 130 to 135 m.p.h. at $2,600? We are sure the dollar is worth less, but still there is considerable discrepancy there.

"We have had some performance and comfort improvements, to be sure, greater engine reliability to be sure, but we feel that all these things have not really measurably increased the airplane's usefulness.

"Can we have—you gentlemen will decide whether it is possible—an airplane that will be quiet and a good neighbor in the community—quiet as to propeller, quiet as to engine clatter and exhaust sounds? Can it get off in 100 to 200 ft.? Can we have one that will require no more than 500 ft. of space for safety in take-off and landing? Is that too much to ask?

"We are told that they exist in N.A.C.A. files. At least it will go far toward those objectives if you engineers can get your managements to spend some money on developing them. That is hearsay with us. We don't know; we aren't engineers or technicians, but we feel that something resembling those characteristics is needed unless we are to continue indefinitely to be a nation of a few fighter pilots. . ."

ENGINEERING ASPECTS OF PERSONAL AIRCRAFT

By

Fred E. Weick

Aeronautical Engineering Department
Agriculture and Mechanical College of Texas

"I WILL TRY TO TOUCH ON just about three of the points that this high-utility personal aircraft should have. In the first place, on the question of noise, I think that the basic element right now is to make quiet airplanes, and the N.A.C.A. has already demonstrated this fact. At the present time, Harvard and M.I.T. are working on a project with N.A.C.A. support which I hope will tell us how far we must go in quieting these airplanes in order to satisfy the public, too, because it is going to be a job to go the full way as indicated by the N.A.C.A. trials.

"That sort of thing will take geared propellers, extremely large motors, and quiet mufflers. It is a tremendous development. As a practical step we have done a little work in that direction at Erco by putting a good muffler on an ordinary light airplane. That is, we took an Ercoupe, put a good muffler on it, and put a four-bladed propeller on it. We got the sound level in decibels down to 75 with the airplane taking off overhead. Now the N.A.C.A. tests showed a reduction from 90 for the untreated airplane to 65, which was very quiet. We also had about 90 for the untreated airplane at a slightly lower altitude as it took off overhead, and reduced it to about 75, which I think is far more important than the reduction from 75 to 65. So I think it is not too far out of line to expect that these present practical airplanes can have their sound levels substantially reduced. . ."

(EDITOR'S NOTE—*At this point Mr. Weick gave the configurations of a hypothetical airplane, having a 35-ft. span, 150-hp. engine, and a weight of 2,200 lbs. Theoretically, it was assumed that this airplane could take off in a distance of 1,600 ft. He then proceeded to calculate the necessary changes in wing area, engine, and propeller to make it possible for this airplane to operate out of a field having a 600-ft. runway.*)

"Now that airplane, while it would carry its full load and get off in 600 ft., could, by using a larger field, carry

a larger load as long as the structure would take it, and it wouldn't require much increase in weight. . .

"It appears to me that we are likely to find it economical to design an airplane that can use the small fields, relatively lightly loaded, and then use larger fields with a larger load if the occasion demands.

"These examples I have taken are just ordinary airplanes, but you can see how to get out of the smaller fields. Now there are some airplanes that have already been designed particularly for that kind of operation. One is the Curtiss Tanager, which you may remember in the Guggenheim competition; another is the Ryan Dragonfly. These are examples of airplanes that would actually operate out of small fields. But you will remember they were both large airplanes for the load they would carry, and they were relatively complex and expensive airplanes for the load they would carry. So that is something we have to watch and consider.

"In my particular examples here I have not considered airplanes equipped with anything special in the way of high lift devices. . . I believe that it would be well worth while to make a serious study of the application of high lift devices of one kind or another to the private airplane. . .

"However, there is one thing we have to do first, and that is to investigate the amount of lift coefficient you actually want to use for these small planes, considering particularly take-off. There is no use having a very high lift coefficient unless you have enough span and enough power to go along with it for the weight you want to carry.

"However, I feel it would be possible to get a simple enough high-lift device that would definitely increase the speed range of these small airplanes. . .

"The third point I want to touch on is this point of having the airplane easy to fly safely. We have airplanes already available that are easy to fly safely under ordinary good weather contact flying conditions, but I think in two respects we need a great deal of improvement. Our new high-performance airplanes—ones that require the private pilot to operate flaps, control the pitch propellers, keep track of the manifold pressure, operate landing gears, and do various other things at the same time he is doing things connected with navigation, or getting into an airport—are a bit complicated for a pilot. This should be simplified substantially, and I think it can be.

"The second point that is unsatisfactory now is flying these private planes in poor visibility; flying them blind. An instrument pilot is really a highly trained specialist, and he has to keep in practice and keep at it all the time in order to do his job safely. In fact, I feel that a competent instrument pilot must combine the physical coordination of a tightrope walker, in holding his airplane straight and maneuvering it in the way he wants to, and the clerical agility of a cashier in one of these supermarkets, where he has to keep track of a large number of facts and figures and know which buttons to push at the right time and which controls to manipulate. There are just too many things for a person to do under those conditions unless he is highly trained and unless he keeps in practice.

"I think it is extremely important that private pilots get to fly their airplanes blind. We have to be able to fly in practically all kinds of visibility—not necessarily all kinds of weather, thunderstorms and things like that—but we have to be able to fly almost regardless of how well we can see.

"We must be able to make a date 2 weeks from now and then leave late enough to take advantage of the speed of our airplane and get there with reasonable assurance and reliability if we are going to have our airplane as a real utility in private transportation.

"I think that we can make these airplanes as easy to fly blind as they now are to fly contact. It will take some work, but it is an interesting problem, and we are going to work on that to some extent at Texas A. & M. I think you can do it basically by making the airplane so it will fly straight if you let go of it so that you can spend your time doing the navigating and the other things that are necessary instead of holding that airplane in the attitude and at the speed at which it ought to be."

PERSONAL AIRCRAFT FROM THE PILOT'S VIEWPOINT

By

Wolfgang Langewiesche

Research Pilot, Kollsman Instrument Division, Square D Company

"I SHALL MAKE TWO POINTS in this discussion. The first point has to do with the airplane's utility—what we really want our airplane to do in order for it to be useful. I will then go into certain technical details as to how we can achieve this utility.

"It appears to me that there is no use for the fixed-wing airplane in our life except as an instrument of long-distance transportation. Even if we do get closer-in landing strips, there still is, to say the least, no real need for anything to supplant the automobile; nor can I see how even a helicopter—which really is the all-time high in short landing ability—could get as close to where we want to go as the automobile can.

"Therefore, I think that long-distance transportation is the thing. If you survey the field, as the Harvard Business School has surveyed it, you will find no evidence—at least you would not have found it a year ago—of any private airplane being used for long-distance transportation. . .

"In order to fly long distances, we have to do a number of things with which I find myself in complete agreement with everyone else who has spoken here. We certainly have to cut out noise. . .

"Noise has a very direct effect on the utility of the airplane. Even if we have good weather, I find that about 5 hours a day of flying is about all the flying a fellow wants to do. He can do 10 hours in one day, but he cannot do 20 in 3 days, and he certainly can't do, shall we say, 150 in a month. It is too much. The noise

being the main element of fatigue, along with vibration, it therefore seriously limits the utility of our present small airplanes.

"There is no reason, no inherent reason, why Cessna, Ercoupe, Luscombe, or any 100 m.p.h. airplane should not be flown 10 or 12 hours a day. We do it with automobiles and we kind of enjoy it, but we can't do it with airplanes because we can't stand the racket.

"The same or similar considerations go, of course, for the problem of short landing and steep take-off. I am of the school who would always take the plane that can take off short and land short, and I would overload it and fly long distances . . . Other people might choose to fly that same airplane light for extreme short landings and short take-offs in order to penetrate into out of the way places. That is a matter of taste. . .

"Now I come to my main point. We were talking about the fact that we need to fly our airplanes long distances. I agree with Professor Weick that we must teach the public how to fly blind. . .

"There is no inherent reason why any one who has had enough of what it takes to make his first solo flight should not also some day make his first solo instrument flight. There is nothing inherently difficult about instrument flying. . .

"Let me try to approach this problem backwards. What is so very, very difficult about instrument flying today? We have several difficulties, each wrapped around the other making a big ball of trouble. On the outside the first thing is air traffic control. If you are flying with instruments and you have a well-equipped ship, you can no longer handle it alone; it is too much of a job; it takes two people to work the system of controls.

"Number two is that our navigational problem in instrument flying, if we do it by the traditional radio range, is extremely difficult. It is easy on paper, but it is not so easy when you remove the paper. . .

"The next difficulty is that, while we try to keep track of ourselves more or less successfully, we also have to control this airplane by means of instruments, which, when we think of the classical instruments, the needle, are extremely crude. . .

"If you take any of our present airplanes under the most practical conditions and turn them loose, or you control them without reference to horizon, they will peal off and curl up. . . The fundamental trouble with our present airplane from the weather flying point of view is that it is unstable as to spiraling.

"As I go at this ball of control again, I will suggest to you that our troubles are all ourselves except the central one. Air traffic control is solved in the sense. . . that airplanes cannot successfully operate under the present system. However, no one has yet been able to think up a better system. At the same time, it is certain that the job will be done. For military reasons we will finally have a system by which the airplane automatically reports itself, automatically reports its destination, and an automatic calculator back in the office does the thinking and signals back to the airplane the direction, speed, distance, and so forth, at which to fly. . .

Francis Arcier, Ralph Upson, and Raymond Hermes (absent when this picture was taken) participate as local representatives with the Panel Group at Dayton.

"Now in the navigation part, we are much further toward a solution. We have the automatic direction finder, which points to the place where it is tuned into and that is altogether a different proposition from a beam. . .

"Now then let us come to the nearest thing to the center of this ball, the instrument. We know that the Sperry people have finally come through with a gyroscopic instrument that will not tumble whatever you do with the airplane. You can loop around, but it will not tumble. Thus, we now have, inside the airplane, a little image, you might say, of the universe which stays in constant relation to the universe and by reference to which you can fly. . .

"That problem is solved, and we will go much further in that respect and finally will arrive at an instrument board that will be in one of several ways so obvious an imitation of reality that you just sit there and fly and nobody has to tell you anything to teach you how to fly with an instrument. . .

"That leaves only that central problem—spiral stability. . . One of the fundamental improvements that we must make in the present fixed-wing airplane before it can be really useful as a means of long distance transportation is to make it stable. . ."

LOSS PREVENTION AND SAFETY

By

Jerome Lederer

President, Flight Safety Foundation

"THE BOOK that Mr. Tully has coauthored states that 'fear of accidents is like sand in the gear box. . .' Fear of accidents directly affects utility. Fear surrounds the airplane with numerous operating limitations designed to improve safety. It raises questions regarding life insurance protection and creates family distrust of the airplane.

"Utility is also affected by the effect of accidents on airplane insurance rates, which make up a sizable part of fixed operating costs. Less than 10 per cent of all aircraft accidents are fatal, but it is the frequency of the nonfatal losses that largely determines hull insurance rates.

"On the average, one airplane in 85 is involved in a fatal accident each year. This figure by itself would not be so bad if the airplanes were used as much as the average air liner. But with the average utilization less than 200 hours per year, a ratio of 1 in 85 is not a credit to the engineering profession.

"Two outstanding causes of fatal accidents are the stall/spin (40–45 per cent) and collisions with obstructions like hills, buildings, trees, and wires (35 per cent).

"About 50 per cent of the stall/spin accidents result from stall only; the other half involved a spin following the stall.

"The elimination of the stall/spin would not reduce the total number of fatal accidents by 45 per cent because about one-third of stall/spins result from buzzing or similar forms of reckless flying... It is reasonable to assume that many of these exhibitionists will find some other way to kill themselves while flying. Nevertheless, the removal of the stall/spin by means already known would reduce the fatality rate from 1 in 85 to possibly 1 in 150... Elimination of stall/spin would also have a marked effect in reducing nonfatal types of accidents. This, in time, should result in lowering insurance rates.

"The collision type of accident... is often caused by reckless flying, such as attempting visual flight under instrument conditions or flying on instruments without knowing how. These accidents are not in the same category as reckless buzzing. Here, the owner perhaps is trying to force utility from his airplane. The engineer must help him to fly in bad weather in a way that will not be reckless. Partial solutions to the collision problem would be the ability to fly slowly in the vicinity of obstructions or a means to detect obstructions such as radar, steeper angle of descent, and, of course, improved vision from the cockpit.

"The time is long past due for establishing standards for vision from the cockpit, especially when one considers that approximately one airplane in every 800 is involved in an air-borne collision each year and that one-third of them are fatal.

"However, collision between aircraft and other causes of fatal accidents play a relatively minor role in the overall tragedy. The other minor causes are composed of forced landings, structural failure, and the remainder result from fire in flight, propeller accidents, taxiing accidents, or causes undetermined.

"Forced landings are more prominent than the others. This emphasizes the need to solve the problem of carburetor ice. Last year at the light plane symposium Mr. Posner of the C.A.A. showed that in a 2-month period there were 57 accidents due to carburetor ice. These resulted in ten washouts, 37 cases of major damage, three fatalities, and four major injuries. The number of forced landings due to carburetor ice in which there was no accident is unknown. He added that the problem could be readily solved, but, if so, there is no evidence of widespread adoption of a solution at this time, one year later.

"On the basis of these records the outlook for improving the safety rests principally on the elimination of the stall/spin, reduction of collision accidents, and, of course, the development of a safer environment for the occupants of aircraft so that when a crash occurs their chances of survival are improved. The engineer must design the weapons out of the cockpit; provide unobtrusive chest straps to be used in emergency landings; avoid structures that trap the legs of occupants when a crash occurs, preventing escape from fire; reduce the chance of fire following crash. The knowledge to accomplish much of this is available. Why not use it?

"With all these features built into an airplane a degree of safety might be achieved that would encourage greater national acceptance of flying. The fatality rate would be much improved, although the total number of accidents would probably continue high.

"This brings us to the discussion of nonfatal accidents. About one in eight airplanes are reported to the C.A.B. as having been involved in an operational accident each year. An equal number of airplanes suffer a nonoperational loss such as windstorm, hangar fire, theft, and hail, so that about one in four insured airplanes present a claim each year to the insurance companies. These average about 35–40 per cent of the value of the airplanes.

"Landing accidents account for 38 per cent of the nonfatal losses; taxiing accidents, 25 per cent; emergency landings, 13 per cent; take-offs, 13 per cent.

"The prevention of these losses lies to a great extent in the hands of the airport manager, the fixed-base operator, and the instructors, but many of them could be reduced by design: viz., there is evidence that the tricycle undercarriage will reduce taxiing and windstorm losses; an airplane that can land in 200 ft. will not be exposed to as many runway hazards like soft spots and snowbanks as one that requires 700 ft.

"A few weeks ago the Fixed Base Operators of New England asked me to expound on the relation of accidents to insurance costs. I selected at random 100 taxiing losses, 100 landing accidents, and 100 windstorm losses in the New England area. I'll brief them as follows:

"A study of 100 taxiing accidents, selected at random, in the New England area, discloses that taxiing accidents in this area occurred to a surprisingly large number of pilots having considerable experience. With the exception of a small percentage, all planes involved were based within the area and were not on cross country flight from other districts. The average cost to the company was $459.53.

"What happened and the extent of damage is shown in Table 1.

"A study of 100 landing accidents in the New England area discloses that spin/stall with 16 accidents are the

TABLE 1
Taxiing Accidents

What Happened	Wash-out	Over-haul	Major Assembly	Minor	Total
Groundloops	..	1	..	1	2
Noseovers and noseups	2	5	17	7	31
Running into ditches, snow, soft ground, etc.	2	9	13	13	37
Collision with other aircraft	..	..	5	4	9
Collison with fixed objects	..	2	4	4	10
Collison with transient objects	..	..	1	4	5
Landing-gear failure	..	..	3	..	3
Accidental retraction of landing gear	..	..	1	1	2
Miscellaneous	..	..	1	..	1
Total	4	17	45	34	100

TABLE 2

What Happened	Wash-out	Over-haul	Major Assembly	Minor	Total
Dragging wing	..	1	..	2	3
Groundloop	..	5	4	..	9
Noseover	1	3	5	1	10
Running into soft ground, ditches, snow, etc.	1	2	8	3	14
Collision with other aircraft	1	..	..	..	1
Collision with fixed objects	..	5	4	3	12
Spin/stall	3	1	8	4	16
Overshooting and undershooting	..	8	5	1	14
Failed to level off	..	3	1	..	4
Wheels up—forgot to lower gear	..	..	1	..	1
Landing-gear failure	1	5	2	..	8
Inadvertently retracted wheels on final approach	..	1	..	..	1
Tire failure	..	..	1	..	1
Miscellaneous	..	2	2	..	4
Unknown	1	..	1	..	2
Total	8	36	42	14	100

most frequent, followed by 14 accidents for both running into soft ground, ditches, snow, etc., and overshooting and undershooting the landing area. The average cost per landing accident was $817.00.

"What happened and extent of damage is shown in Table 2.

"There is a vast amount of knowledge available to reduce accidents by design. For years this has been discussed at great length at technical meetings such as this, but the migration from the discussion stage to adaption had been slow. The new look is needed in aviation—let's have less talk—more action."

HIGHLIGHTS OF GENERAL DISCUSSIONS

Mr. George Tweeney (*Guest Panel Speaker, Detroit*): "As most of you know, we have studied this private aircraft problem locally for some time. We have talked about it and discussed it, too, and, as I sat here listening to the other presentations, I couldn't help but reflect on some of the points that we have discussed. I am more than ever brought around to this single conclusion:

"We have heard discussions on safety, we have heard discussions on cost, we have heard discussions on instrumentation, we have heard discussions on noise, we have heard statistics, we have heard everything that leads or points to this one basic central point: As engineers, we have to design a new airplane.

"What that configuration will be I don't propose to guess or predict, because I don't know myself, but as an airplane designer, in thinking of the utility of the private airplane, I should not sit down to my drawing board to prepare a balanced diagram by drawing a vertical axis and a horizontal axis and immediately say to myself: 'The propeller goes here, the engine goes here, the instrument board goes here, the cabin goes here, the wing goes here,' and so on.

"In other words, we are too hidebound by convention. The technical data are available for us to build this new type of airplane, and, as we design it and build it we must put into it each of the points that these gentlemen have made. It must be safe, it must be quiet, it must be easy to handle, it must be spirally stable. . ."

Mr. Peter Altman (*Guest Panel Speaker, Detroit*): "I have no quarrel whatsoever with any of the statements that were made by the previous speakers. In fact, I think they threw out a challenge to us to accomplish the necessary in order to make private flying, personal flying, a real business venture. At the same time, if we study the facts, I don't think it is necessary or desirable, for that matter, to cry wolf and run and hide. I think the industry has made a fairly good record for itself; perhaps not the best record that some of us would like to see but still a good record. . .

"I wish to mention convertible aircraft and show how we might combine the qualities of the airplane and the helicopter. The most important and most detrimental of all airplane characteristics is control at low speeds. Fortunately, in military aircraft today a great deal of work is being done on what they call proportional control so that your control portions vary with the speed of the aircraft. . . As far as convertible aircraft are concerned, there are two general classes: one in which the rotor is started and stopped in flight, a rather difficult thing to do; the other in which the rotor becomes a propeller in flight. . ."

Mr. E. Burke Wilford: "Such a combination of features offers interesting and attractive possibilities not only as a means of increasing the utility and safety of the passenger plane but as a military weapon in the guided missile field. . .

"These possibilities are now being studied on a broad front and numerous experimental aircraft and models incorporating these unusual features actually have been test-flown over the past decade. . ."

Mr. Stalker: "I happen to be interested in the matter of boundary-layer control and presently engaged in the use of it in some of the components of jet engines.

"Boundary-layer control today is commonly called in terms of drag production and so-called low drag wings where we simply achieve the reduction by creating special wing contour in which the variable pressure is maintained along the cord, but there are other aspects

of the volume air control problem which I am sure will become more and more familiar to all of you. . .

"There is a close relationship to the matter of drag reduction and the increase of the maximum lift. Experiment and theory have both shown that we are not using anywhere near the ultimate in the achievable lift coefficient. Experiments show, for instance, that you can obtain lift coefficients to the order of 7 out of relatively simple wings and that you can reduce the drag of wings down to coefficients something like 0.01, whereas the present-day figure is something on the order of 0.005. These figures point out the potentialities.

"One of the things that might readily come about, if we have to go to greater powers, for instance, to achieve shorter take-off, is to make use of this power to achieve something in high speed. At present, if you require 300 hp. to get off in a short distance, then you waste most of that 300 hp. in trying to go fast with it. Whereas if you were to use a good portion of that power, or some of it, to reduce the drag coefficient down from values as we know them today something like 205 to 201, you would really be getting benefit out of that power.

"I don't think that boundary-layer control is an answer to all the problems of the airplane. This problem, for instance, of adequate directional stability and spiral stability is, I think, primarily one of designing proper surfaces and proper relationships to each other. However, if this were achieved, I think there is another aspect of boundary-layer control in that it can be utilized to achieve spinproof airplanes and variable control airplanes. . .

"I think there would be many opportunities to fly airplanes under rather bad weather and increase the facility of the airplane by actually arriving at your destination if we had an airplane that was capable of flying slowly enough under adequate control. Boundary-layer control does offer some possibilities in that field."

Professor Locke: "I think it is entirely out of reason to expect the human race to advance itself to an entirely new method of locomotion or transit within the space of two generations. For that reason I welcome the unconventional, possibly new configuration of aircraft.

"I am thinking particularly of rotary-wing aircraft of some kind—some type of convertaplane, for example. . . a rotary-wing aircraft in which the tail rotor can be rotated 90° to provide thrust, thereby giving you a vehicle in which you have the relatively high speed that Mr. Langewiesche asks for. You have possibility of hovering, getting under bad weather, finding your way out of the stuff, and landing and taking off in short fields. . ."

Mr. Jerry Gordon (*Guest Panel Speaker, Wichita*): "We have had extremely well-qualified gentlemen discuss what we need in private aircraft. It has been

The Panel at work. ***From left to right:*** **Fred E. Weick, Wolfgang Langewiesche, Arthur H. Tully, Jr., Grover Loening, and Jerome Lederer.**

suggested that what we need are slow landing speed and short take-offs and all our problems will be solved. I say, let's look at the record.

"The records show that the public will not buy any one thing; they will buy overall utility. To compromise myself, an airplane sufficient to get 200- or 300-ft. take-off distances and short landing distances will produce what I like to call a unipurpose airplane that only a certain class of people will buy. I think the future will produce an airplane like that when the market becomes large enough that enough people can use an airplane like that.

"Today we have built the kind of airplane that we can sell, and unless we sell more airplanes we are not going to get a chance to design new ones and build new ones. . . I think the record is clear that we have sold performance and we have sold utility. . . Private flying, to get increased utility, must make it possible for people to operate during a great percentage of the weather.

"It is true that in Kansas the percentage of flying weather is large, but it is also true that, if you plan to use the airplane 1 day a week and that day you have instrument weather, you are not going to use it. And so 3 or 4 hours of instrument weather may reduce your utility as much as 25 to 50 per cent.

"In the Beech questionnaire in which all the owners were asked how big a factor weather was, the rough average answer was that weather reduced their utility by as much as 25 per cent. . .

"In closing, let me voice the plea that we tell the public what we have and not spend our time bemoaning our unfortunate lot. We have a usable product. Progress will not be made by going back 15 years to produce the type of 90-m.p.h. cruiser airplane that we had in those days. Let's get the pilot, the public, the operator, and the owner together. . ."

Mr. Kenneth Razak (*Guest Panel Speaker, Wichita*): "Speaking as one who is engaged in the business of education, I think we have two responsibilities. One, of course, is education, and in our case it is aeronautical engineers. But expansion of flying depends to a large extent upon the education of a large group of people as to the benefits of flying as much as it does upon the development of a technically perfect airplane.

"If an airplane were available immediately which is capable of hovering over a spot with perfect ease and requires no particular technical skill to operate, we would still have to spend considerable time educating enough people with the aircraft and overcoming their inherent fear of getting both feet off the ground at the same time with no additional connection with the earth. . .

"We in the aeronautic education business can do a great deal in the way of basic research on new forms of aircraft, while the company that is engaged in the building and selling of the present form of aircraft should also be engaged in the search for better aircraft for years to come. It is true that the long-range research and research that requires expensive wind tunnels and other large laboratories must usually be done in schools or in Government laboratories. . .

"There is not enough technical information on boundary-layer control, flaps, induced flow, convertible propeller arrangements, and many other technical features. After more experimention on combinations of these, events or conditions should make it possible to produce an aircraft that is capable of a speed range of zero to 200 m.p.h. It won't look like anything that is flying now. . .

"Of course, the biggest question in developing such an airplane is that it would be so new and radical that it probably would have little acceptance at first, and it would take, again, more and more education to have such an airplane adopted. . ."

Chairman Loening (*In answer to a question from the floor*): "At N.A.C.A. we have been much impressed with the possibilities of the convertaplane. It is a machine that would rise vertically under rotor control, and then gradually go on to fixed-wing conditions.

"In order to start to bridge that gap, we have been looking around to see what the thing warranted in the way of research and particularly to get at least a half dozen smaller subjects of research that we can farm out to the universities. The laboratory at Langley Field at the present time is engaged in doing the first step, which is to determine what happens when a rotor is taken from its 90° position of lift into a horizontal position of propeller and whether or not that can be done with any kind of efficiency. . .

"However, as you know, there are two sources of bridging this gap from zero to 200 m.p.h. One is to rise under rotors and then fly on the fixed-wing régime. The other is to use air lift that is reduced to a fixed wing either by blowing air on to it or boundary air control or the creation of new vortex patterns or something that will fool the fixed wing into thinking it is flying at 60 m.p.h. when actually it is standing stationary and can rise vertically off the ground.

"That is within the bounds of possibility and is one of the subjects that Ken Razak, for one, and Fred Weick at his laboratory at the Texas A. & M., and many others around the country are going to go into. So that there are some moves in that direction, and the helicopter is one solution only. There are other solutions."

Tom Salter: "I would like to ask the Panel a simple question. These airplanes all lack utility and are expensive; they are too noisy; you can't climb up through the weather; and everybody is scared to get into them. Can you tell me why the boys seem to keep buying them?"

Mr. Hermes (*Guest Panel Member, Dayton*): "I enjoy these sessions particularly because we, as engineers, can stand around and dream of the many wonderful things we can do with these airplanes. There is certainly lots of room for improvement, I am sure. We undoubtedly have to design these airplanes so that they can take off in short spaces. We would like to have them go 200 m.p.h. and cruise rapidly, and we have lots of things to learn about safety.

"I enjoyed particularly the fact that there has been so much unanimity between the gentlemen on the Panel. I believe that they have at this meeting hit upon the crux of our whole problem—that is, the problem of dependability. . .

"Until we get some kind of a gadget that we can go from here to there and back, not when the weather man tells us we can or when the wife says that she thinks the weather is just about right, but when we want to go, when we have to go, we will not have a vehicle that we can market in volume.

"A refrigerator would be of no value to anyone unless when you put in that little plug and you needed ice it would work. . . That, as I see it, is the main trouble with the personal aircraft industry. We just can't go there and get back when we want to.

"I believe that the methods have been adequately covered. Mr. Langewiesche has brought out a good point—that we first have to have the instruments, we have to have an airplane that has spiral stability. Most of you, I presume, are familiar with the Teleran setup that the R.C.A. has been working with. It also is a method of simple navigation under instrument conditions. True, the development costs are terrific, but it is one approach. I hope Mr. Langewiesche can come up with one that is less expensive.

"I hope that Jerome Lederer does not take me to task afterwards for neglecting his important item of safety. Safety is important. We have to realize it. We don't place enough emphasis on safety. But I believe you must agree with me that an airplane is just as safe as you want to make it. It depends entirely on the

pilot, on how the pilot, the personal operator handles things.

"I can give you a few figures offhand; there might be a little discrepancy in some of them. They show that 65 per cent of all accidents are caused by pilot error. I think that approximately 15 per cent are due to power-plant failures. But, if we actually analyzed those, I think over half of these are actually personal errors—you run out of gas, you accumulate carburetor ice, you don't use the carburetor control properly, or you don't switch your tanks properly.

"The structural failures are classified as 4 per cent; at least half of those are due to maintenance. However, I would say almost 100 per cent are due to maintenance. When you add the 65 per cent, over half of the power-plant failures due to personal errors, and most of the maintenance problems to the same thing, and then go back and analyze the terrain and weather accidents, which are also a matter of pilot error, actually about 95 per cent of all accidents are due to pilot error—error in judgment. That in itself indicates that, compared to the automobile accident rate where you have approximately three fatalities per 100,000,000 miles, in the aircraft industry, if you eliminated the pilot error, you would have approximately five to seven fatalities per 100,000,000 miles. It depends on the pilot and how he wants to handle his own airplane..."

Mr. Ralph Upson (*Guest Panel Member, Dayton*): "I very much dislike that term 'pilot error,' perhaps because I am such an indifferent pilot myself. But every time I hear that oft-quoted expression I get angry because it seems to me that the principal item of dependability Mr. Hermes has so eloquently called for is the very one of dependability against the pilot's own mistakes, and the engineer cannot laugh off any kind of pilot error, if you choose to call it that, that is repeated many times.

"If we are any good at our jobs we ought to be able to figure out, as I know we can in many of these cases now, ways to prevent a pilot from going into a stall, spin, and various other things that are going to get him into trouble.

"Many of the remarks that have been made this evening might, it seems to me, be boiled down into simple conclusions such as this: That we have gotten to the point in airplane design where you can really have almost anything that you want; except you can't have everything all at once, at least not yet.

"Forty years ago there occurred a great historical event—the very first sale of a bona fide two-place airplane. Supposedly, it was a military craft, but it hadn't any particular military features. So we may as well call it by what it was, an airplane sale... Also it seems to me it had a span of around 36 ft., a gross weight of around 1,200 lbs., and an empty weight of around 800 lbs.

"So far it sounds a good deal like a modern light plane, doesn't it? Well, in some ways it was better. Of course, it only had top speed of around 42 m.p.h., and it would spin and get into nose dives that we would have to pull it out of. However, it would land short and take off short. I believe, with a modern Reynolds Number correction for the airfoil and, assuming a reasonable lift coefficient of around 1.2 to the wings, this would give the light plane a landing speed of around 33 m.p.h.

"The interesting thing is that the modern light plane with present-day wing loadings could achieve that same landing speed in still air if we used modern flaps and slots and what is generally known as available to the art.

"There are plenty of reasons why lots of people don't use such things, which is just another way of illustrating the point I made before—that you can have most anything you want but that you can't have everything all at once.

"Therefore, we are going to have to get together, users and designers, and decide what is the most important thing and how important it is to have these various things and to what extent it is desirable to get the landing speed down or to get the noise down or to get stability...

"Two years ago at the light plane meeting, one of our speakers made a most interesting analysis, which no one disputed, to the effect that potentially the personal airplane can be the most economical power means of transportation that there is, bar none, just provided it is flown enough hours. How are we going to get that? We can't get it out of the personally owned airplanes ordinarily. We have got to work out some system so that each plane can be used more hours and justify its use in that way.

"And so it seems to me, finally, that it is up to the manufacturers and agencies to coordinate with the fixed-base operators in that respect, and it is up to the fixed-base operators to forget about every other source of income that they may have—I don't mean forget about it but put them secondary to what is going to be the major item, and that is rentals. They must get programs started, methods installed, and effective improvements and regulations begun which will minimize, not extend the time that is necessary for training and everything else that may interfere with the successful operation of airplanes."

Mr. Brown (*Director of Aviation of the State of Ohio*): "It seems to me that, until the psychological approach to training in the colleges and the schools is picked up and they try to find better techniques and put research into the development of training, we are not going to go very far. We know right now that manufacturers are building airplanes that spin simply because the C.A.A. has that as one of its requirements. Look at all the expense the manufacturers have gone to to make it spin...

"You mentioned that we need more of a middle-age spread in aviation. We are also trying another thing... and that is the utilization of the four-place airplane.

We are using a four-place plane, something similar to the old CCC cross-country course. We have wondered if it weren't possible—and we believe the four-place manufacturers are enthusiastic about it—to use that equipment in the initial training, trying to get the student accustomed to a new medium.

"It seems to carry out certain educational principles in allowing the student to compare himself with other people of equal ability and not to a superman who is sitting up in front, and sometimes not a bright superman at that. Also, it gives him a chance at a little competition, the three of them in there with an instructor. It gives them a little more courage, a little more self-reliance, and, most important, it gives the operator a reason to own a four-place airplane and the manufacturer a reason to build. . ."

I.A.S. National Meeting Schedule

Wright Brothers Lecture—Washington, D.C.—December 17, 1948

Seventeenth Annual Meeting—Hotel Astor, New York, N.Y.—January 24–27, 1949

Members or organizations wishing to submit papers for presentation at National Meetings should send outlines or summaries to the Committee at least 3 months prior to the meeting.

All papers submitted will be considered for publication in the *Journal of the Aeronautical Sciences* or the *Aeronautical Engineering Review*.

All correspondence should be addressed to The Meetings Committee, Institute of the Aeronautical Sciences, 2 East 64th Street, New York 21, N.Y.

Feature Articles in Forthcoming Issues

"A Study of Wing De-Icer Performance on Mount Washington," by D. L. Loughborough, Howard E. Green, and Paul A. Roush, The B. F. Goodrich Company

Summary of the Technical Sessions of the I.A.S. Annual Summer Meeting

Report on Joint I.A.S.-S.S.A. Technical Sessions at Elmira, N.Y.

"Inert Gas Installation," by H. W. Naulty, Cornell Aeronautical Laboratory

"Propeller Considerations for High-Speed Aircraft," by Harold H. Warden, Propeller Division, Curtiss-Wright Corporation

The Helicopter Control Rotor*

by
JOSEPH STUART, III
Project Engineer,
United Helicopters, Inc.

SUMMARY

It is shown that a conventional helicopter is difficult to fly because of the excessive rolling and pitching velocities and the poor natural damping of these velocities. Heavy control stick loads and friction, tendency to stick whirl and vibration, and aircraft instability are also noted as contributing to helicopter piloting difficulties.

To remedy these deficiencies, a safe aerodynamic servo, in the form of a control rotor, has been developed. It is introduced between the pilot's control stick and the cyclic pitch input to the lifting rotor.

The design considerations proportioning the control rotor and its control input and output linkages are described. An improved analysis of the hovering stability and control of conventional and control-rotor-equipped helicopters is also presented.

Flight tests show that the desired control response, aircraft damping and stability, and smoothness of control stick action are all achieved in practice. A helicopter that is both easy and pleasant to fly is thus at last a reality.

INTRODUCTION

CONVENTIONAL, DIRECT CYCLIC PITCH CONTROL, single lifting rotor helicopters almost invariably exhibit three serious control deficiencies:

1. The helicopter is extremely difficult to fly.
2. The helicopter is unstable.
3. The cyclic pitch control stick has objectionable characteristics.

That conventional helicopters are difficult to fly is well known. Pilots have actually overturned smaller helicopters while over-controlling in their too zealous efforts to keep their machines upright.

That conventional helicopters are unstable has been amply demonstrated by the gyrations of free-flying, articulated-blade helicopter models.

That cyclic pitch control sticks in conventional helicopters have objectionable characteristics is known by every helicopter pilot. The most prominent of these objectionable characteristics are: (a) a time variation of stick resistance to motion resulting in a "notchy" stick action, (b) high friction forces and other loads, (c) stick vibrations, (d) a tendency to stick whirl in the direction of rotor rotation, and (e) a lack of any centering tendency to restore the displaced stick to its neutral position.

The helicopter control rotor effectively overcomes all three major deficiencies. It gives a smooth control stick in a stable helicopter that is easy to fly.

* Part I of a paper presented at the Rotating Wing Aircraft Session, Sixteenth Annual Meeting, I.A.S., New York, January 26–29, 1948. The second part, or Appendixes, of this paper, giving the mathematical configurations and technical data, has been deleted because of space limitations. Copies of the entire paper are available in preprint form and may be obtained from the I.A.S. Preprint Department.

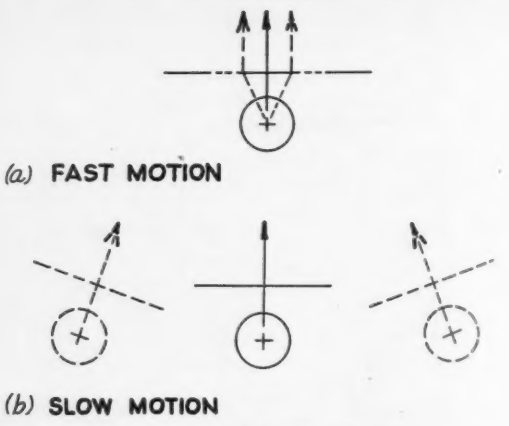

FIG. 1. Control fixed, free motions of helicopters.

CONVENTIONAL HELICOPTERS' STABILITY CHARACTERISTICS

In the past it has been common practice to conclude that helicopters are difficult to fly because they are unstable. A brief examination of conventional helicopters' stability characteristics will show that there is no direct connection between the two.

There are two basic types of fixed-control, free oscillations possible in single lifting rotor helicopters: (a) a fast motion in which the lifting rotor stays substantially horizontal and the body oscillates as a *torsional* pendulum about the aircraft's center of gravity; and (b) a slow motion in which the lifting rotor stays substantially perpendicular to its drive shaft and the aircraft as a whole executes a translational oscillation.

For the case of a two-passenger helicopter with a conventional control configuration, a complete analysis gives for these motions,

	Fast Motion		Slow Motion	
	Period, sec.	Multiplications per cycle	Period, sec.	Multiplications per cycle
Rolling	1.99	0.00009	13.3	1.55
Pitching	(Aperiodic)		14.7	3.67

where multiplications per cycle greater than unity indicate growing, unstable motions, and conversely.

For this conventional helicopter the fixed-control, fast motions are so highly damped as to be substantially undetectable. The unstable slow motions at first glance appear to be the major villains. However, as Donovan and Goland[1] have pointed out, the long periods of these motions should make them subject to easy pilot control. The fact that these instabilities are not the all-important factor in helicopter piloting is definitely proved by two observations regarding piloted helicopter accidents. In the typical case:

(1) The period of the controlled amplifying oscillation coincides with neither natural motion's period. (In one two-passenger helicopter case, for example, the rolling period was 3.75 sec.)

(2) The destructive controlled amplifying oscillation takes place about the low-inertia roll axis, rather than about the pitching axis, about which the aircraft is much more unstable.

The conclusion seems inescapable that it is not primarily the instability characteristic of conventional helicopters that makes these aircraft difficult to fly but, rather, *control characteristics* that make overcontrolling all too easy for inexpert pilots.

CONVENTIONAL HELICOPTER'S CONTROL CHARACTERISTICS

A two-passenger airplane and a conventional two-passenger helicopter's maximum roll rates and roll damping rates are calculated to be:

	Maximum Roll Rate, Rad. per Sec.	Damping Rate, at 1 Rad. per Sec.
Airplane	0.713	11.7
Helicopter	1.395	3.25

Helicopter flight results have indicated that a maximum rolling or pitching rate of but 0.5 rad. per sec. assures adequate control for the critical precision hovering, quick stop, and rough-air handling maneuvers.

This fact and a comparison of the above airplane and helicopter values shows that conventional helicopters: (1) reach unnecessarily high final roll (and pitching) rates and (2) provide relatively little damping for steady angular velocities.

These two factors, aggravated by the pilot's being forced to use a rough, noncentering control stick, give ample support to the contention that conventional helicopters' control characteristics encourage overcontrolling.

CONTROL ROTOR SYSTEM FUNCTIONS

Conventional helicopters' control and stability characteristics would be vastly improved if it were possible to slow down their main rotor following rates to a fraction of their present values. Such rotors would be sluggish and lag much further behind their bodies to

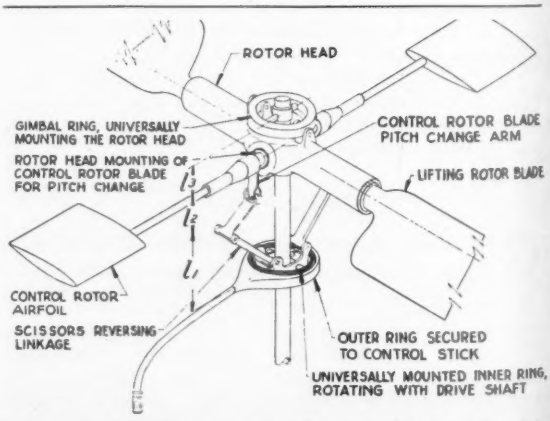
ROTOR HEAD
GIMBAL RING, UNIVERSALLY MOUNTING THE ROTOR HEAD
CONTROL ROTOR BLADE PITCH CHANGE ARM
ROTOR HEAD MOUNTING OF CONTROL ROTOR BLADE FOR PITCH CHANGE
LIFTING ROTOR BLADE
CONTROL ROTOR AIRFOIL
SCISSORS REVERSING LINKAGE
OUTER RING SECURED TO CONTROL STICK
UNIVERSALLY MOUNTED INNER RING, ROTATING WITH DRIVE SHAFT

FIG. 2. Schematic diagram, Hiller simplified control rotor linkage.

give several times more damping in steady rolling or pitching motions.

On larger helicopters where this decreased following rate would not give an adequate maximum rate of rolling or pitching, the necessary maximum rate could be obtained by multiplying the controlling gimbal ring's maximum tilt the requisite number of times.

But building a set of lifting blades five times heavier would result in a helicopter incapable of lifting even its own empty weight. And, in any event, a practical configuration, single lifting rotor, direct control helicopter would always be slightly unstable.

Instead of heavily weighting the large lifting rotor blades, it is much more practical to build a small control rotor having low aspect ratio and thus low lift curve slope airfoils. Even at the weights per square foot of the original lifting rotors such a rotor has a following rate but a fraction of that of the full radius lifting rotor, when turning at the same r.p.m.

By controlling the lifting rotor blade's cyclic pitch only by the control rotor, the control rotor is dominant, and a rotor system of the desired sluggishness and damping is obtained. As a happy consequence of the interactions of the *two* rotors, the resulting helicopter is also stable.

As initially suggested by Stanley Hiller, Jr., the desired maximum rate of roll or pitch may still be obtained by multiplying the maximum control input given the control rotor by the pilot's control stick.

As there is no mechanical connection between the control stick and the lifting blade's pitch changing, the control rotor functions as a safe aerodynamic servo device, completely isolating the pilot's control stick from the roughness originating in the deflections and loadings of the large lifting rotor blades.

A Typical Control Rotor System

Fig. 2 shows a control rotor system suitable for a two-bladed lifting rotor helicopter.

The pilot's control stick puts cyclic pitch into the small control rotor. The resulting cyclic flapping of the control rotor blades puts cyclic pitch into the lifting rotor to effect control of the helicopter.

The ingenious simplified linkage shown was developed by Mr. Hiller. It permits: (1) direct control through an overhead control stick (no added reversing mechanisms are required); (2) direct mounting of the control rotor blades upon the rotor head to achieve maximum control system rigidity; (3) easy incorporation of control input multiplication; and (4) easy incorporation of feedback.

The two last items, shortly to be defined, are important refinements. No added parts are required for their accomplishment.

The following ratios may be defined:

L = input ratio, fraction of control gimbal ring tilt used for control rotor cyclic pitch (usually greater than 1)

$L = l_1/l_2$

Fig. 3. UH-5 Helicopter mounted for simulated high-speed flight.

P = output ratio, fraction of control rotor flapping used for lifting rotor cyclic pitch

$P = 1$ (control rotor is built onto rotor head)

X = feedback ratio, fraction of lifting rotor flapping used for opposite control rotor cyclic pitch (usually from 0 to 1)

$X = l_3/l_2$

Two other parameters of primary importance are the lifting rotor and control rotor following rates. These are the absolute rates these rotors would follow a conventional gimbal ring or wobble plate, leading the particular rotor by an angle of 1 rad. The dimensional rates are:

N = lifting rotor absolute following rate, rad. per sec., per rad. lag

G = control rotor absolute following rate, rad. per sec., per rad. lag

Control Rotor Design Considerations

Control rotors must be designed not only to give the desired control, damping, and stability characteristics under ideal hovering conditions but also to function successfully under all flight conditions. Although aircraft forward speed alone imposes no important restriction upon control rotor design, a control rotor in practice must:

(1) Be able to generate a controlling moment large enough to overcome unbalanced blade drags acting upon lifting blades deflected away from their cyclic pitch change axis, under accelerated flight conditions. (The lesser moments caused by lifting blade stalling or bearing friction may be critical for flap hinged blades.)

(2) Have a flapping inertia greater than the maximum inertia created, perpendicular to the control rotor span, by the upward bending of the lifting rotor blades under accelerated flight conditions.

(3) Have a sufficient tip speed and cyclic pitch range to give full lifting rotor cyclic pitch control and also neutralize the effects of: (a) curvature in the flow

field, induced by the aircraft body; (b) blanketing of the rear portion of the control rotor disc by the stalled wake from the cabin roof encountered at very high body attack angles; (c) local high velocity flows through the control rotor disc permitted by stalling of the inner portions of the retreating lifting rotor blades.

These three major considerations will determine minimum control rotor radius, blade area, cyclic pitch range, and flapping inertia. On minimum diameter control rotors they also make desirable the use of low aspect ratio airfoils giving extraordinarily high stalling angles.

Conservative accommodation of item (3) above has in recent designs dictated control rotor cyclic pitch input ratios (L) of about 2.5 for cases in which the controlling gimbal ring or wobble plate has the conventional $\pm 8°$ or $\pm 10°$ tilt range.

With the value of L fixed, the control rotor following rate necessary to give the desired maximum equilibrium rolling (and pitching) rate may be established to fix the final control rotor parameters.

Under steady rolling (or pitching) conditions, neglecting the effects of sideslip of the rotor caused by its not being upon the aircraft's c.g.:

$$\text{Lifting rotor, } PcN = \dot{a}_{max.}$$

$$\text{Control rotor, } (Lb_{max.} - c)G = \dot{a}_{max.}$$

Eliminating c gives

$$\dot{a}_{max.} = GLb_{max.}/[1 + G/PN)]$$

or

$$G = \dot{a}_{max.}/[Lb_{max.} - (\dot{a}_{max.}/PN)] \qquad (1)$$

Feedback, X, is used primarily to adjust the stability characteristics of the helicopter, and its selection, depending upon more subtle considerations, is discussed in a later section.

Control Stick Centering

Through the use of control rotor airfoils having minimum inertias about their pitch change axes, a truly smooth and light control stick is a readily accomplished reality.

As our test pilot, Frank W. Peterson, had previously indicated, however, a completely nonresisting control stick is not desirable. In accordance with his recommendations, centering springs giving a control stick grip restoring rate of about 1 lb. per in. are now used.

Centering springs (1) give the pilot a feel sense of his stick's displacement; (2) discourage overcontrolling by beginners; (3) prevent the pilot's inadvertently taking off with the lifting rotor tilted (by an uncentered control stick); and (4) provide, when adjustable, simple trimming means.

Complications such as hydraulic dampers, friction dampers, or irreversible elements are not necessary or desirable for control rotor system sticks.

Stability and Control Analysis Comments

Single lifting rotor helicopters, using a tail rotor for torque correction, have pitching inertias roughly four times greater than their rolling inertias. In consequence, their rolling and their pitching, stability, and control phenomena are substantially independent.

Analyses were accordingly set up to consider motions in but one plane.

To further simplify the analytical work, the lifting and control rotor's responses were considered to be accurately described by a single readily calculated parameter—the rotor's following rate. This is defined as its absolute angular rate of following per unit angular lag behind its static equilibrium position.

Although Kelley[3] has used a following rate concept to describe the motion of Young's stabilizer bar, the use of this concept to describe the motion of control and lifting rotors is believed to be an important simplifying innovation.

The response of a rotor of any number of blades to cyclic motion of its control gimbal ring has been rigorously analyzed. The results were compared with those given, very much more simply, by the following rate concept. The following rate concept was shown to be adequately accurate for practical helicopter stability and control work.

As the small effect of the lateral profile drag of the sideslipping rotor has not been included, the analysis is rigorously correct only for rotors having blades of zero profile drag.

Stability and Control Analysis Results

The typical two-place helicopter has been analyzed, and the results as a conventional helicopter, a control rotor helicopter without feedback, and a control rotor helicopter with feedback are given in Table 1.

The aircraft control response sensitivity is defined as

$$Z = \frac{\text{aircraft angular amplitude}}{\text{control gimbal ring amplitude}}$$

when the control gimbal ring is being rocked by the pilot's control stick in a motion of 4-sec. period. (Motion pictures of overcontrolled rolling in a conventional helicopter showed a 3.75-sec. period.)

Control rotor effects are seen to be: (1) The slow motions are made stable and their periods are lengthened. (2) The excessive rolling response sensitivity has been remedied. (3) The response sensitivities in roll and pitch have been substantially equalized. (4)

Table 1
Comparative Stability and Control Characteristics

Configuration	Motion Axis	Fast Motion Period, sec.	Fast Motion Mult. per cycle	Slow Motion Period, sec.	Slow Motion Mult. per cycle	Response Sensitivity Z
Conventional	Rolling	1.99	0.00009	13.3	1.55	6.00
	Pitching	(Aperiodic)		14.7	3.67	3.13
Control Rotor, $X = 0$	Rolling	1.091	0.645	41.6	0.66	1.544
$L = 2.5$; $G = 1$	Pitching	2.11	0.371	40.7	0.696	1.924
Control Rotor, $X = 1.172$	Rolling	1.05	0.400	41.6	0.673	1.53
$L = 2.5$; $G = 1$	Pitching	2.06	0.096	41.5	0.730	1.70

FIG. 4. Hiller 360 Helicopter, incorporating feedback.

The fast motions remain stable, but they are less highly damped than in the conventional helicopter.

The major effect of feedback (X) is seen to be its improving the damping of the fast motions. However, as it rapidly reduces the damping of a steady rolling or pitching velocity, it should be used with discretion.

FLIGHT TEST RESULTS

Before any high-speed, control rotor flights were made, a single-seater helicopter, equipped with a control rotor, was mounted upon a truck and operated at speeds up to 50 m.p.h. at 40 per cent of its normal rotor r.p.m. Speeds of up to 125 m.p.h. were thus simulated at several rotor angles of attack. The control rotor system functioned satisfactorily in these preliminary tests.

But the final proof of any primary control system is found in the flying qualities it produces in actual aircraft.

Insofar as approximate flying quality checks can show, the theoretical analysis trends have been verified 100 per cent in practice. The actual flying qualities have proved to be far better than anyone dared anticipate from the bare analysis results.

Many pilots of varying skill have flown the single-seater helicopter shown in the lead-off picture of this article. With trim controls incorporated, this helicopter has been hovered hands-off for periods of 45 sec. and longer repeatedly. Airplane pilots with no previous helicopter time have been taught to hover this single-seater machine in times as short as 8 min.

The three-passenger Hiller 360 model helicopter shown in Fig. 4 has already been autorotated and flown to 80 m.p.h. without incident. Its control rotor system includes a limited amount of feedback.

CONCLUSIONS

(1) The following rate concept gives relatively simple stability and control analyses, that yield useful information.

(2) The helicopter control rotor is a simple, inherently reliable, low cost device which: (a) changes the helicopter from a tricky machine requiring a highly skilled pilot to an aircraft that is basically easy to fly; (b) changes the helicopter from a basically unstable aircraft to one that is basically stable; (c) changes the conventional rough, heavy control stick to one that is smooth and light and has a "feel"; (d) provides reliable aerodynamic servo power of sufficient magnitude to make pilot control of large rotors practical; (e) provides a means of reducing the aircraft control response sensitivity of tiny helicopters to the ideal value for easy flying.

(3) Something can be done about conventional helicopter control system deficiencies.

Conclusion (2) really means that the helicopter control rotor has finally made it possible to build helicopters of all sizes which are both easy and pleasant to fly.

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Flight Path Control

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IT IS TRITE TO SAY that the most serious obstacle to economic health and continued growth of commercial aviation is the inability to keep schedules in bad weather. This is universally recognized, and the industry is currently engaged in the establishment of an overall plan for air-traffic control utilizing radio aids, such as the Instrument Landing System (ILS) and Ground Controlled Approach (GCA) for approach conditions, as the omni-range working in conjunction with Distance Measuring Equipment (DME) to provide means for on-course control, as well as various orbits for holding.

While the picture is by no means clear as to what the final air-traffic pattern will look like, all these systems, and any foreseeable system, have one thing in common—they require the airplane to be flown along a prescribed flight path, either straight or curved and either level at a definite altitude or at a definite angle to the ground. Now it so happens that this is psychologically a difficult job to do manually. The pilot's whole training and experience have been to correct for errors in attitude about the c.g. of the airplane, and now he is faced with the necessity of performing a time integration of attitude in order to correct the observed error. While a skillful pilot can do nice job of it for a short time, it requires his constant attention. As a matter of fact, it is so fatiguing that to fly accurately in this manner for a period of hours, as would be required in a cross-country flight, is completely beyond human endurance—the job must be done automatically.

To meet this need, all manufacturers of automatic pilot equipment for air-line use are intensively engaged in the development of devices to accomplish flight path control—generally with specific reference to the ILS approach beam. As is the case with every engineering development, the final result will of necessity have to be a compromise among many factors. In our contacts with air-line and air-frame people it has become evident that no clear understanding exists as to just what these factors are, although proper weighting of them will require the close cooperation of all concerned.

The purpose of this paper is to present the problem from the point of view of the autopilot engineer, discussing some of the factors involved in the final compromise. Although exhaustive study of the various methods of control which have been tried, or are possible, is beyond the scope of this paper, it is purposed to develop the geometry of the problem and to present a few typical solutions, evaluating them with respect to the overall compromise and pointing out, where possible, just what limitations are fundamental and what can be expected to be overcome in future equipment and with the development of improved radio techniques.

While some radio systems yield a more simple geometrical pattern, let us consider the problem in relation to the one of most immediate interest—the ILS localizer beam. Referring to Fig. 1, an airplane at point A is considered to be attempting to achieve flight path B–C which is set up by a transmitter at B. Now the signal received in the airplane and presented on the cross-pointer meter is substantially proportional to the angle subtended by a line including the airplane and the transmitter and the desired flight-path line. This angle is designated by σ in the figure. Now if the linear error be x and the slant range d,

$$\sigma = \sin^{-1}(x/d) \tag{1}$$

or

$$\sigma = x/d \tag{2}$$

for small angles, also

$$d\sigma/dt = (1/d)(dx/dt) \tag{3}$$

considering d a constant. Also, if we define the heading α of the airplane, neglecting crab, as the angle between the actual flight path of the airplane and the desired flight path, then

$$dx/dt = (ds/dt)\sin\alpha \tag{4}$$

$$dx/dt = v\alpha \tag{5}$$

for small angles, and

$$x = \int v\alpha dt \tag{6}$$

Also from Eqs. (3) and (5)

$$d\sigma/dt = (v/d)\alpha \tag{7}$$

From the above, some important relationships may be gleaned. First, it will be observed that, in the expressions for signal and rate of change of signal relative to the linear error, d appears in the denominator. This means that, as the transmitter is approached, the signal controlling the system and its derivative, if used, become progressively greater and would go to infinity except for two factors: Saturation is bound to occur in the circuits, and the beam becomes more or less hyperbolic at short ranges. As will be developed later, this gives rise to a tendency for overcontrol at short range. Secondly, it will be observed [in Eq. (7)] that under

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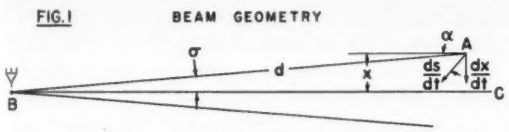
FIG. 1 BEAM GEOMETRY



1. $\sigma = \sin^{-1} \frac{x}{d}$ 4. $\frac{dx}{dt} = \frac{ds}{dt} \sin \alpha$

2. $\sigma = \frac{x}{d}$ (small angle) 5. $\frac{dx}{dt} = v\alpha$ (small angle)

3. $\frac{d\sigma}{dt} = \frac{1}{d} \frac{dx}{dt}$ 6. $x = \int v\alpha \, dt$

7. $\frac{d\sigma}{dt} = \frac{v}{d} \alpha$

given conditions heading is the equivalent of a signal derivative. This point will be elaborated later.

Since an analysis employing differential equations and considering aircraft and autopilot characteristics is out of the question, stability characteristics of the systems under discussion will be investigated by use of the frequency spectrum method. While this method is so well known as not to require comment (having been covered in papers by Nyquist, Hall, Prince, and others), it was felt well to include a brief description for the benefit of those not engaged in servomechanical work.

Referring to Fig. 2A, we may represent any linear servomechanism by a block diagram such as the one shown, wherein each block may represent an element in the system (such as autopilot, amplifier, autopilot servo, aircraft dynamics, beam geometry, and the like), connecting them in series if they act on each other in turn or in parallel if their effect is additive. Each one of these elements when excited with a sinusoidal forcing function can have only two effects: The output relative to the input is, in general, shifted in phase and changed in amplitude. In making the analysis, the servo loop is opened at any convenient place and a sinusoidal forcing function introduced. At any given frequency this function may then be carried around the loop, being amplified or attenuated, and shifted in phase by each element in turn until finally a vector representing the output is obtained, Fig. 2B. As the frequency of the forcing function is varied, so will the output vector vary in accordance with the system parameters, the locus of the end of this vector forming what is known as a transfer function. Since the amplitudes here considered are nondimensional ratios, the actual amplitude is immaterial as long as the system is linear. The criterion for damping in the analyses consists in the output locus passing inside -1 relative to the input. While this matter has been covered in detail (Hall: *The Analysis and Synthesis of Linear Servomechanisms*), for our purpose it will be sufficient to consider that the farther inside the locus passes the more effective the damping, while instability is indicated by an enclosure of the -1 point. It should be noted that if a system is nonlinear with respect to a given parameter, a single locus is valid for only a single value of that parameter. Actually, a family of curves is required to be drawn to get the complete picture. It should further be noted that each block in the system might of itself be a complicated system. This is immaterial as long as the corresponding transfer function for such an intermediate system can be evaluated. For instance, in the analyses that follow, it has been convenient to lump the complete autopilot and airplane together and treat these elements as a single block.

FIG. 2A

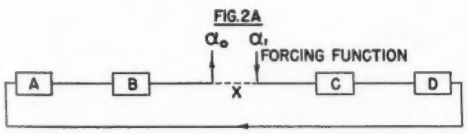
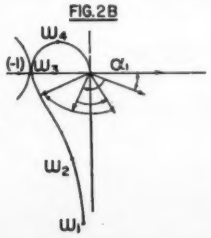


FIG. 2B



A few words regarding the evaluation of the transfer functions belonging to the various system elements may be in order. There are, of course, several methods available. If one is dealing with an existing system, the method of physical test is, no doubt, the most satisfactory. However, if the problem is one requiring synthesis, analytical methods must be used. Since this paper is not intended to be a treatise on servomechanisms, it does not seem necessary to go into detail on this point; however, the methods used in obtaining the loci shown were those of conventional mathematics. For instance, if a forcing function $\theta_1 = \theta_{1_0} \sin \omega t$ is operated on by a system element that performs a simple integration, the output is $\theta_0 = (k\theta_{1_0}/\omega) \cos \omega t$, and the nondimensional amplitude becomes (dividing output by input) k/ω with a phase lag of 90°. (K will include any transformation ratios that may be involved in the particular case.) In cases where vectorial additions are involved, graphical methods have been employed. The transfer function for the airplane, a B-25J equipped with a PB-10 autopilot, was arrived at using time constants obtained by flight tests.

Before proceeding with the analysis of any system, it may be well to enumerate the requirements that should be met. Assuming adequate control of the airplane through the autopilot, the flight path control equipment should:

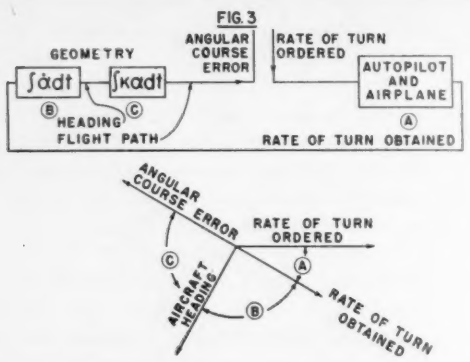
(1) Be stable over the usable range of air speeds and, if possible, slant range without adjustment.

(2) Be capable of correcting for large amounts of initial error, cross-wind, and unfavorable trim moments without appreciable flight path error.

(3) Produce coordinated turns.

(4) Produce no violent maneuvers for physiological and structural reasons.

FIG. 3



Let us look briefly at a rudimentary system, where rate of turn of the airplane is ordered proportional to angular course error (see Fig. 3). In the block diagram, it will be seen that the forcing function, rate of turn ordered, is converted by the airplane into rate of turn obtained—this is integrated to produce heading obtained; again integrated and multiplied by V/d to produce angular course error. The phase shifts and amplitudes introduced by these operations are indicated in the vector diagram. It will be noted that the double integration of itself involves a 180° phase shift, so that the locus of the output vector must, for any value of system parameters, include -1. This system is, of course, highly unstable, and some method of advancing phase must be included.

One possibility of obtaining phase advance is to employ some means of reading rate of change of signal. One practical method is to drive some lagging element with the signal and subtract its output from the driving signal. This yields a leading component whose amplitude is a function of the ratio of driving frequency to the time constant of the device. Fig. 4 shows the nondimensional amplitude of the leading component of such a device having time constants of 5 and 20 sec. through a frequency spectrum of zero to 0.625 rad. per sec. More complete information is given in Fig. 5 which shows total gain and phase lead of a circuit including such a device for three different time constants through the same frequency spectrum. It should be noted that at a frequency where the phase lead is 90° (zero) the amplitude is zero and at a frequency where the amplitude is unity (infinity) the phase lead is zero.

Notice should be taken of the straight line in Fig. 5 which represents the value of amplitude of a true derivative having values corresponding to the 90° component of the 20-sec. T/C lagging element circuit at its peak frequency. It should be especially noted that, while the true derivative increases without limit with frequency, the lagging element system saturates so that increasing frequency produces no greater amplitude beyond that point. This is a valuable characteristic, as will be shown later.

Refer now to Fig. 6 (case I), which shows the rudimentary system but with the addition of the rate system just outlined. The vector diagram is similar, but a vector addition of the rate circuit output to a portion of the angular course error signal is required to yield the total output. Since the system is nonlinear with respect to V/d, a family of transfer function loci is required. This is shown in Fig. 7. V is considered as constant as 125 m.p.h., so the curves indicate stability at actual distances as noted in the figure. The sensitivity assumed was a 180° per min. turn ordered with a signal equivalent to the cross-pointer against the stop. It is of interest to note that, while the system is highly stable at 2 miles, as the station is approached it rapidly becomes worse, so that at 0.5 mile an extremely unstable condition is reached.

Assuming circuit linearity, a system such as this yields phase relationships that do not vary with range, amplitude or gain being the only factor involved. It is therefore possible to introduce some attenuating element in the system and vary this as range varies, so maintaining stability. As a matter of fact, systems employing this principle have been successfully flown. However, we do not consider adjustment with range desirable, preferring to obtain this characteristic as an inherent part of circuit design, if this be possible.

Before proceeding further, it may be well to discuss briefly the matter of signal derivatives. It was mentioned earlier that the use of a lagging element does not yield a true derivative. Even if such a function could be obtained circuitwise, it would not be particularly desirable. As the linear sensitivity increases while approaching the transmitting station, there is, of course, an increase of the natural frequency of the system. If a circuit element is included which increases its effect with an increase of frequency, without limit, more and more violent control will be exerted on the airplane.

There is another source of high frequency. Short period instability in modulation systems, circuit noise, interference from other aircraft, etc., combine to produce a small amplitude "quiver" in the needle at a very high relative frequency. This would, of course, in a true rate system show up in large amplitude motions of the control surfaces.

Another point should be mentioned. In our analysis we have assumed our input data—the localizer beam—

FIG. 4

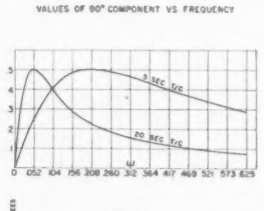


FIG. 6

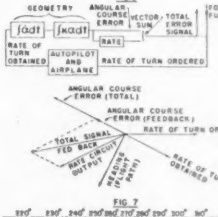


FIG. 5

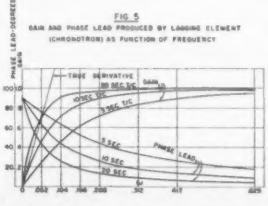
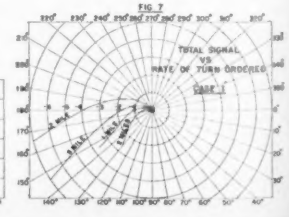


FIG. 7



to be a perfectly straight line. As is well known, this is not realized in the actual beam. Occasionally, apparent bends exist which have true geometrical meaning. Without elaborating the point, it is well known that, if one takes a derivative of a function having small irregularities, the function representing the derivative will contain these irregularities—magnified out of all proportion to the original function. This means that a system using a true signal derivative will be unduly sensitive to course bends, ordering maneuvers of the aircraft which are not actually justified by the defects in beam geometry involved.

The use of a lagging element to obtain phase advance, which is involved in the system of Fig. 6, does indeed have, in some measure, all the faults developed above. However, since saturation with increasing frequency occurs, it is possible to so choose a time constant and amplitude ratio that overly violent effects are avoided—at the expense of phase lead at the higher frequencies.

Without arguing the point further, what is really desired is rate of change of linear error. In Fig. 1 it was shown that this function is $V\alpha$ or true air speed times the difference between actual flight path and the desired one. To be sure, we cannot conveniently obtain α, but the heading of the airplane relative to the beam bearing is nearly the same thing. Introduction of this element, of course, brings with it its own difficulties. In the first place, it is necessary somehow to introduce beam bearing data into the system before a given beam can be flown. In the second place, the system becomes inherently proportional—and the necessary crab angle for compensating for cross-wind requires a constant signal and, hence, a radial path other than the desired one. The first item can be accomplished either by feeding in beam bearing through a dial before beginning the approach or by maneuvering the airplane to beam heading before engagement. The latter method is perhaps the more practical, provided sufficient capacity of error "soak up" is available. The second item, that of obtaining crab angle without constant error, requires some form of integration. This again can be accomplished in two ways—we can integrate the error signal with time or "wash out" the opposing signal, in this case the voltage representing airplane heading relative to the beam. This latter method has the advantage that it can be conveniently accomplished by static circuit elements, whereas the former is difficult to do without moving parts.

FIG. 8

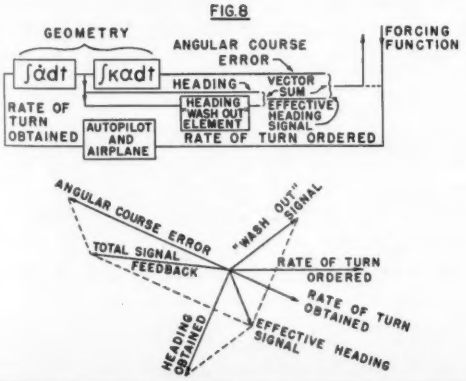
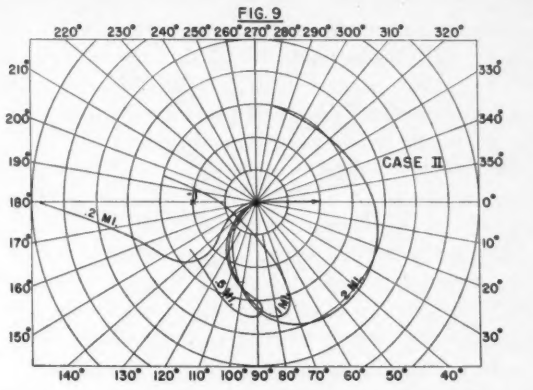


FIG. 9



Refer now to Fig. 8, which represents a system made up to the elements just discussed (case II). In this one, two vector sums have to be taken: (1) the heading signal and its opposing "wash out" signal, and (2) this resultant and the course error. This is shown on the vector diagram. Fig. 9 shows the transfer function loci at the same ranges and sensitivity as were used for Fig. 7. We notice two peculiarities: All curves are similar and highly stable at the high-frequency end of the spectrum, but at the low end there is a tendency to loop back to a point where low-frequency instability is arrived at some point depending on system parameters. In the figure this occurs somewhere between 0.5 and 1 mile. At greater ranges, of course, there is no stability whatever. It is possible by circuit adjustment providing incomplete "wash out" of heading signal to achieve passable performance with this system, and a great number of successful flights have been made with it. However, more complete stability is desirable, so we must look further.

We notice, in comparing case I with case II that in some measure opposite characteristics are manifest; case I, while highly stable at large values of slant range, becomes unstable on approach to the station, whereas case II, while excellent at close ranges and high frequencies, becomes useless at some greater distance depending on the system parameters. This being the case, the thought of combining the two naturally presents itself. Remembering our discussion regarding signal derivatives, we will content ourselves with the minimum required to achieve long-range stability. Furthermore, we will employ a lagging element to obtain this leading component and adjust our circuit constants so that when the resultant of this signal and the course error signal degenerates to a high level displacement signal, which it will at high frequencies, the level so obtained will not be such as to produce violent maneuvers, as was discussed before.

FIG 10

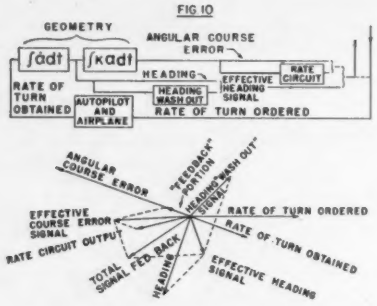
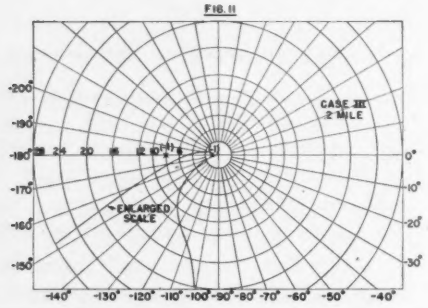


FIG. 11



Such a system is shown in Fig. 10 (case III), the vector diagram showing how the various signals are added. The transfer function locus for one distance (0.2 mile) is shown in Fig. 11. This system combines, of course, the characteristics of both case I and case II. There is now no problem of low-frequency, long-range instability. The short-range, high-frequency stability is not quite so good as case II, but appears to be reasonable. As a matter of interest, Fig. 12 shows the performance of a case III system on a simulator currently in use in our laboratory.

There is an important difference between case I and case II which should be discussed. In obtaining signal phase advance by any sort of lagging element, the process essentially consists of taking the difference between a displacement signal and a washout signal that has a time lag. If a step function signal is introduced to such a system, the output signal will be instantaneously proportional to the amplitude of the step function signal. Now, for reasons that have been discussed before, the output signal generated by such a step function input cannot be much greater than that yielded by a simple displacement system under similar conditions. As a matter of fact, the sensitivity used in preparing the transfer function loci in the two cases utilized the same value of step function sensitivity. This means that any system using signal derivatives will inherently have a low order of long-term sensitivity as compared with a displacement system having a comparable control activity. In practical terms, this means that any out-of-trim condition tending to turn the airplane, such as unsymmetrical power or wings not level, will show up eventually as a constant angular course error. This is true with either system, but since the long-term error is inversely proportional to the long-term sensitivity, the effect is much worse in a system of the type of case I. In the practical application of case III, which shares this fault, it was found necessary to add an integration term. Since this added element saturates at perhaps 2–3 per cent of the total possible output and since it has such a long time constant (3–5 min.), the effect on the transfer function shown in Fig. 10 is practically nil.

It is felt that case III, with the addition of the integration term mentioned above, represents the best compromise using the elements under discussion. While theoretically it requires preset data, in practice it has been found possible to use large enough amounts of heading washout signal to swamp completely the displacement signal at its maximum value, thus permitting turns of any angle provided sufficient distance from the station is available to allow for the geometry involved.

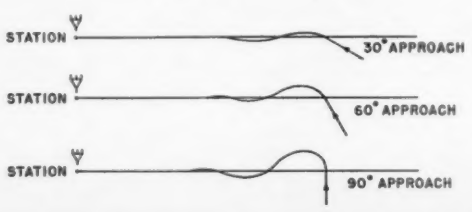
In addition, orbiting paths are possible by merely removing heading from the argument during this operation. Since, under this latter configuration, the system functions according to case II, orbit radius must be great enough so that operation will occur in the stable region. While this has not been investigated to date, offhand it would appear possible to adjust orbit signal to a level consonant with stability for any radius likely to be utilized.

So far no mention has been made of glide path control. While the problem is essentially the same as localizer, it is in many respects much less difficult. In the first place, the airplane time constants are much shorter because coordinated turns, with consequent delays in obtaining bank angles, are not required. In the second place, the range variation is not so great, since glide path is used normally only a short time; also "beam softener" expedients, which produce more or less hyperbolic patterns, are in vogue. These latter are helpful. However, there is one point that should be mentioned, and that is the question of pitch attitude versus power control.

It is an aerodynamic fact that an airplane with a given gross weight and indicated air speed will maintain a constant angle of attack relative to the incident air without regard to whether its flight path is parallel to the ground or not. The power required for level unaccelerated flight will be just enough to overcome the total drag. If we attempt to change the flight path relative to the ground by changing the pitch attitude (for example, nose up), the resultant configuration is one requiring more power, since now, in addition to supplying the drag, we have to do work on the airplane to raise it.

FIG. 12

PERFORMANCE OF CASE III SOLUTION ON SIMULATOR



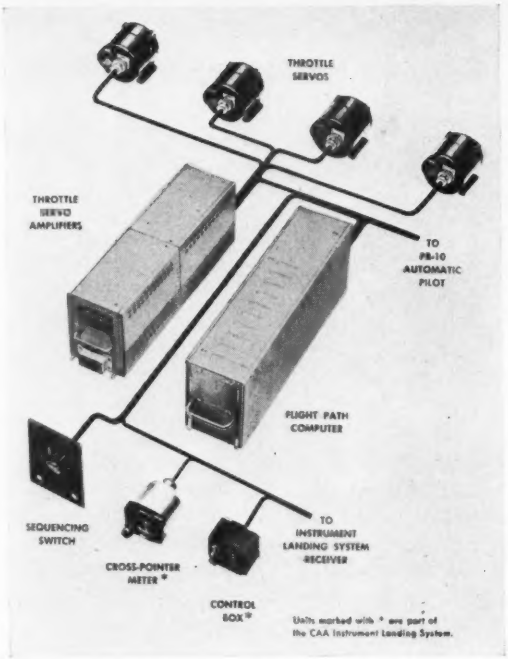

THROTTLE SERVOS
THROTTLE SERVO AMPLIFIERS
TO PB-10 AUTOMATIC PILOT
FLIGHT PATH COMPUTER
SEQUENCING SWITCH
CROSS-POINTER METER *
TO INSTRUMENT LANDING SYSTEM RECEIVER
CONTROL BOX *
Units marked with * are part of the CAA Instrument Landing System.

FIG. 13.

During the period when kinetic energy is available from the mass of the ship, the desired flight path will be obtained, but, as this is dissipated, air speed will drop until a new equilibrium point is established at a lower air speed and higher angle of attack. Whether the resultant flight path is a climbing one or not will depend on what part of the speed range the initial air speed was—it may even have the wrong sign if near the stall. In the case of nose down, of course, the same thing happens in reverse. It therefore appears evident that divergence is possible if control is attempted by pitch attitude alone, especially under the critical conditions of landing. If we now attempt to modify vertical flight path by controlling power alone, we find that, while we get climbing or diving paths without danger of inversion, air speed does to some extent change, although not nearly so much as before; furthermore, while the time constants involved in pitch attitude changes are relatively low, troublesome lags are encountered in engine control. It appears, therefore, that the solution must involve both pitch attitude and power control.

To obtain the necessary power component, we have three choices:

(1) We may do it manually. This involves watching air speed and applying the necessary correction. Since a considerable amount of kinetic energy is available from the airplane, this method will work, but it requires constant attention at a critical time, and since human responses are necessarily slow, a lagging component may be thrown into the argument inducing control instability.

(2) We may read air speed and control throttles automatically. This is much better than (1) but does still introduce a lagging element, since air speed itself must lag through a large angle. If a system stability can be obtained, it should be effective, although requiring the complication of an extra signal.

(3) We may apply power and pitch attitude together. This method requires the proper proportioning of power and pitch attitude to obtain constant air speed, which seems quite practicable to do. It does not require the addition of an extra signal and has no lag except that of the power plant itself. For this reason stability is inherently much better, and response to gusts is about as good as can be accomplished. This method on the whole appears to be the most desirable.

Without elaborating further, satisfactory results have been secured with a glide path system exerting control by method (3), and employing a dynamic solution similar to case III, using "wash out" of the opposing signal (pitch attitude). In use, any adjustments of air speed desired during the approach can be obtained by varying the pitch attitude through the autopilot controller. While not the ultimate, it does appear to be a good solution for the current need.

Fig. 13 is a photograph of the equipment, currently being marketed, by the Bendix Aviation Corporation. This equipment comprises the Flight Path Computer, containing both localizer and glide path circuits; throttle servo, one or more of which are employed depending on the situation; and the throttle servo amplifier, used in quantities demanded by the servo installation. This equipment employs a case III solution for both localizer and glide path, with parallel control of throttle and pitch attitude as described above. Monitor circuits are provided to guard against circuit failure, which might introduce a violent maneuver, the operation of which in case of failure will cause the system to revert to straight autopilot control and light a warning light. Interlocks are provided so that all foreseeable miscontrol due to failure of the pilot to follow the proper operating procedure is avoided.

FIG. 14.

While circuit and airplane limitations prevent the complete realization of the stability characteristics indicated in the case III analysis, the equipment nonetheless provides satisfactory stability, permitting the maintenance of control on localizer on a go-around directly over the station. The equipment, in addition to providing localizer control from ILS signals, permits one to fly the VHF ranges automatically without discomfort.

It may be of interest to mention the lagging device used for rate and "wash out" circuits. This element shown in Fig. 14 is known as a Chronotron. It comprises two arms of a thermally controllable bridge, control of which is exerted through the medium of a pair of electrically insulated heaters, the necessary time lag, of course, being provided by the thermal inertia. Since the envelope is highly evacuated, it depends entirely on radiation for its operation so that position and changes of atmospheric pressure do not affect its operation.

While it is easy to set up an ideal solution and to demonstrate by the methods employed in the present discussion that such a solution will work, there are many limitations, from the nature of the problem, that must be taken into account in attempting to evaluate what a given system may be expected to furnish in the way of performance. In some cases, stability itself may be involved. It is therefore desirable that some of these limitations be explored.

We have already mentioned the presence of "bends" in the localizer beam and have attempted to design our system so as, at least, not to magnify them. We have also seen how the generation of an error signal as an angular function rather than a linear one has caused stability difficulties not entirely overcome. There are others. The ILS system is supposed to furnish a proportional signal through an arc of 10° either side of the centerline. As a matter of practical experience, this proportional zone is really only dependable through an arc of $2^1/_2°$—the zone covered by the cross-pointer meter.

If we attempt to operate in the region outside of this proportional zone, we find our signal derivative, on which we depend for damping at the longer ranges, either zero or even occasionally of the wrong sign. We therefore must avoid this zone Referring to Fig. 15, let us look at the geometry of the situation. Assume an airplane traveling at, let us say, 140 m.p.h. true air speed, intersecting the localizer at an angle. Now it is desired that the airplane make a turn to the localizer without getting outside the proportional zone. As shown in the figure, an approximate value for this angle is $\cos^{-1}[1-(\sigma d/r)]$. Now, with a 20° bank angle, the radius of turn at 140 true air speed is such that at 3 miles from the transmitter only 36° initial error can be allowed. This, of course, assumes the airplane turns at a constant rate. Since the system necessarily will not order this, the allowable initial error will be considerably less. Without attempting to evaluate this factor exactly, it appears that to reliably soak up 45° initial

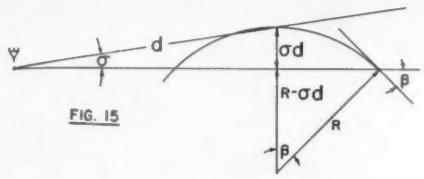


FIG. 15

1. $R \cos \beta = R - \sigma d$

2. $\beta = \cos^{-1}\left(1 - \frac{\sigma d}{R}\right)$ (APPROX.)

error, at least 10 miles initial range will be required. Of course, we can use higher bank angles and lower air speed, but there are other troubles.

The apparent location of the center of the beam depends, in most installations at least, somewhat on aircraft attitude. In most of the cases with which we have had experience, as the airplane is banked to make a correction, the beam apparently moves in such a direction as to increase the error, only to snap back when the ship is again level. This, of course, produces instability. While this matter is an extreme variable with installation, it makes the desirability of limiting bank angles paramount. It should be mentioned that at close ranges (over the station) this matter of attitude effects probably makes system stability impossible regardless of other considerations.

So far the only remedy for attitude effects which we have found practicable, outside of obtaining the best possible air-borne antenna location, has been to limit bank angle. In the equipment shown in Fig. 13, two bank limits are available. A variable one, providing a bank up to 45°, is adjustable to whatever value the aircraft's antenna situation will permit. This is used during the process of orientation to the localizer where tight turns are required and attitude effects are least evident. A fixed one of approximately 5° is also provided. This is used during the actual localizer run and also for range flying. As to lack of stability over the station, this is without doubt academic, since the airplane passes through this region so quickly that nothing much can happen. At the worst, the most violent maneuver that can be ordered will still call for only a 5° bank because of the limiter.

Let us review some of the compromises that have to be made in order to achieve a practical system:

(1) In order to obviate the necessity for accurate preset data and to compensate for cross wind, we are required to employ some form of integration, which takes, in our system, the form of a "wash out" signal.

(2) Employment of the integration or "wash out" signal introduces a phase lag that becomes effective to produce system instability at large values of slant range, therefore requiring a phase advance or rate system to restore stability at these ranges.

(3) Introduction of the phase advance element brings with it three undesirable effects:

(A) The system to some extent tends to be unduly conscious of needle "quiver" and short radius bends.

(B) Stability at close ranges tends to be impaired.

(C) Long period sensitivity, in adjusting system parameters to take (A) and (B) into account, is greatly impaired, requiring the addition of another element, long-period signal integration, to compensate for residual airplane turning moments.

(4) We should like to be able to accept large values of initial heading error at close ranges, but, for stability, we must maintain signal proportionality forcing us to make the initial turn at a greater distance than we would like, since the reliable region of proportionality furnished by the beam is rather narrow.

(5) We could improve matters as far as item (4) is concerned by making a tight turn, which, of course, requires a large bank angle. This brings with it, however, the matter of attitude effect, which, by distorting the apparent position of the beam, destroys stability. We must, therefore, limit bank angles.

(6) Finally, we may be forced so far away from the station by the above considerations, that at low altitude the signal itself may fail, causing an apparent saturation of the radio system and failure of proportionality at less than full scale on the meter. Thus we are forced, finally, to limit the amount of initial error that can be tolerated almost in inverse proportion to the quality of the radio link.

We may at this time draw a few conclusions:

(1) Stable control may be achieved over a wide range of slant ranges by the use of signal derivative plus heading, using integration to remove constant error.

(2) Glide path requires the control of power in some manner, the most desirable being deemed to be direct proportion to signal.

(3) Regardless of inherent system stability, the initial error that can be dealt with dependably is limited by beam geometry and attitude effects.

All things considered, however, the situation is not too dark. Provided the limitations are recognized, current radio and control equipment is capable of good enough performance to permit reliable approaches to at least the minimum conditions being considered (200 ft. and 0.5 mile) and at the same time provide a comfortable ride when controlling to ranges. Current equipment can also furnish orbiting paths at such time as radio signals are available for this purpose.

For the future we intend to explore every possibility that appears practicable to improve the equipment for which we are responsible. To the radio people, the writer would like to submit the thought that a signal representative of linear error rather than angular error would go far in improving stability. Perhaps an even better solution would be a pattern somewhat hyperbolic in nature, providing a wide proportional band at the region where the beam is entered, with a narrower region of higher, but relatively constant, sensitivity along the runway. If this cannot be done, the practical elimination of attitude effects and increasing the reliable proportional region of the localizer beam would be a tremendous help.

To the air-frame manufacturer, we should like to suggest that throttle control is of necessity going to be a factor. Consideration of this matter in the design of throttle systems, with regard to space requirements and minimum lost motion in throttle linkages, will effect substantial savings.

To the operators, the writer would like to respectfully request continued patience in arriving at the final solution to this problem. Meanwhile, if flight routines and procedures are set up with full cognizance of the limitations involved in current equipment and beam geometry, practical improvement of schedules is in sight.

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Notice to Readers

The articles, "A Study of Wing De-Icer Performance on Mount Washington," by D. L. Loughborough, Howard E. Green, and Paul A. Roush, and "An Inert Gas Installation for Aircraft Fuel Tanks," by Howard W. Naulty, scheduled for publication in this issue, are being held over until September and October, respectively.

I.A.S. Briefs

Summaries of current papers accepted for publication or presentation at I.A.S. Meetings

Shear Stress Concentration and Moment Reduction Factors for Reinforced Monocoque Cylinders Subject to Concentrated Radial Loads*

By

N. J. Hoff, Vito L. Salerno, and Bruno A. Boley

Polytechnic Institute of Brooklyn

Investigations carried out in the last few years have shown conclusively that the conventional methods of stress analysis give an incorrect value for the maximum bending moment in a ring frame of a reinforced monocoque cylinder subjected to a concentrated radial load. As a matter of fact, common sense works better in this case than the simplified engineering theory. When a weight is suspended from the lowest point of the ring of a circular fuselage, common sense would anticipate large bending moments in the ring in the neighborhood of the load and negligibly small bending moments at the top of the ring. Nevertheless, engineering theory, based on time-honored assumptions that are entirely correct in the case of the solid beams of civil engineering, predicts a secondary maximum of the bending moment to occur at the top of the fuselage. According to these calculations, the secondary maximum at the top assumes a value equal to one-third of the primary maximum bending moment that appears at the point of load application.

A more rigorous analysis that makes no use of the customary simplifying assumptions yields results in good agreement with the anticipations based on common sense. Unfortunately, calculations of this more rigorous type are extremely time-consuming. The authors intend to enable the airplane structural designer to make use of the results of such calculations without excessive work. For this reason they are presenting a series of graphs from which the maximum bending moment values can be read directly when the geometry and mechanical properties of the structure are known.

The diagrams also contain information regarding the shear stress concentration occurring in the sheet covering of the monocoque fuselage in the neighborhood of the concentrated load.

It was found that the maximum shear stress was often about ten times as large as that calculated by elementary theory, while the maximum bending moment in the ring was often only about one-third of that determined by conventional methods. All the results shown in the diagrams were obtained through calculation. Experiments carried out by the N.A.C.A. and by the Polytechnic Institute of Brooklyn showed good agreement with theory.

* Presented at the Annual Summer Meeting, I.A.S., Los Angeles, July 14–16, 1948.

Please do not order Preprints of these papers at this time.

See page 48 for Preprints that are immediately available.

Some Aeroelastic Properties of Swept Wings*

By

S. I. Pai and W. R. Sears

Cornell University

The problem of the lift distribution on an elastic airfoil is re-examined, especially from the standpoint of the sweptwing. It is shown how, using matrix notation, the problem can be set up and solved in a general class of situations. A peculiar characteristic of swept wings is the considerable influence of wing bending on load distribution.

As examples of this procedure, certain typical cases involving sweptback and swept-forward wings are treated. Some effects of sweep on aeroelastic properties are known, such as the effects on torsional divergence speed and aileron reversal. These are confirmed, and the aeroelastic effects on stability derivatives are also investigated. It is demonstrated that these effects may be much greater than in straight wings.

Finally, it is suggested that in swept wings the influence of wing bending on aerodynamic load may be important in dynamic cases. For example, wing bending may couple with airplane pitching and vertical motion to produce a variant of the common "short-period oscillation" of airplane dynamics. The equations of motion appropriate for this case are set up, and the effects of sweepback and elastic properties are investigated.

The Relative Merits of Rotary Compressors

By

D. G. Samaras and R. A. Tyler

National Research Council of Canada

The relative merits of various types of rotary compressors are assessed in the light of the available test data that could be considered sufficiently reliable for the purpose. The theoretical grounds on which such an analysis may be legitimately made are discussed, and the strict requirements of the theory

* Presented at the Annual Summer Meeting, I.A.S., Los Angeles, July 14–16, 1948.

are relaxed sufficiently to enable a graphical comparison to be made on the simple basis of small stage efficiency and load factor. The resulting curves are interpreted with due allowance for the necessary departure of this representation of the test data from that required by the theory. It is concluded that the various types of rotary compressors are each characterized by a particular value of the load factor, at which the efficiency for the corresponding compressor type is a maximum and departure from which involves a comparatively rapid loss of efficiency. Furthermore, the data analyzed and the theoretical considerations indicate that the maximum efficiency increases from one compressor type to another of lower characteristic load factor. As a result of this it would appear that the axial-flow compressor is, currently, more efficient than the centrifugal type to the extent of about 10 per cent.

The Application of Metallurgy to Aircraft Design*

By

Leo Schapiro

Douglas Aircraft Company, Inc.

The art of metal manufacture and heat-treatment develops new metals that find application in aircraft design when they are an improvement over a previously used material in respect to one or more of the following properties: strength, corrosion resistance, formability, machinability, weldability. Several such developments that have taken place in the past decade, that are taking place now, and that promise to be completed in the next decade are discussed. The metallurgical developments discussed relate principally to the property of strength and the metallurgical principles basic to producing high strength in nonferrous and ferrous materials are outlined and compared. Attention of aircraft designers is directed to some present developments in metallurgy which can mean new construction metals in the next decade.

Application of Simultaneous Equation Machines to Aircraft Structure and Flutter Problems*

By

P. A. Dennis and D. G. Dill

Douglas Aircraft Company, Inc.

Engineering problems are progressively requiring the use of more and more powerful mathematical methods, and these methods are conversely simplifying problems that were formerly difficult to solve. Calculating machines of many types are also becoming increasingly well known and applied. The simultaneous equation calculating machine makes a valuable step forward in furthering these trends.

Flutter, divergence, and control surface reversal are problems that require considerable mathematical effort and present trends are leading to a prohibitive amount of computation. In this paper a mathematical representation is made in the form of linear algebraic simultaneous equations. Other aircraft engineering problems susceptible to similar treatment are listed. A computing machine capable of solving these problems is described, and sample problems are solved.

This technique of formulation of these problems and their machine solution leads to a substantial timesaving over conventional methods and also allows great flexibility in examining the effect of various parameters.

* Presented at the Annual Summer Meeting, I.A.S., Los Angeles, July 14–16, 1948.

Jet Propulsion in Commercial Air Transportation*

By

Robert E. Hage

Boeing Airplane Company

In the field of military air transportation speed trends have been continually upward, and recent flights of new Air Force high-speed jet bombers have caused much speculation as to the future of jet-propelled aircraft. In commercial air transportation, the goal of the air lines in satisfying the public demand has been, and always will be, increased speed, especially if at the same time improvements in safety, comfort, reliability, and economy result. Can jet propulsion, which has so revolutionized military aviation, be applied to advantage in civil air transportation?

To evaluate this problem a number of generalized studies are set up to show the effect of airplane, engine, and performance variables. A careful analysis of variables, such as availability of engine types, fuel requirements, take-off and climb performance, block-to-block speed, comfort, direct and indirect operating costs, profitable operating ranges, and desirable airplane size, leads to a prediction of future trends in civil air transportation.

It is concluded that the adoption for commercial use of 30-passenger turbojet transports, operating at 35,000 ft. at cruising speeds of 500 m.p.h. for nonstop ranges of 250 to 1,000 miles, can be both technically feasible and commercially profitable for 1951. This type of transportation will offer to the commercial air passenger more speed, greater flight frequency, and more comfort at fares comparable to present standards. The air-line operator will be offered a single-type transport that will efficiently service over 80 per cent of the domestic air business. Skip-stop transcontinental schedules at high block-to-block speeds for all flight ranges will promote greater per cent pay-load factors and smaller fleet sizes. This high utility should guarantee a greater profit for the air lines.

It is believed that the immediate development of a prototype tubojet transport will speed the development of turbojet power plants, airport facilities, air-line procedures, and the overall efficiency and growth of the American commercial transportation system. Furthermore, a reserve of highly efficient transport aircraft will be available for military service in a future emergency.

* Presented at the Annual Summer Meeting, I.A.S., Los Angeles, July 14–16, 1948.

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134 The Transient Reaction of a Two-Dimensional Wing at Supersonic Speed Due to Change in Angle of Attack—Chieh-Chien Chang, Associate Professor, Department of Aeronautics, The Johns Hopkins University

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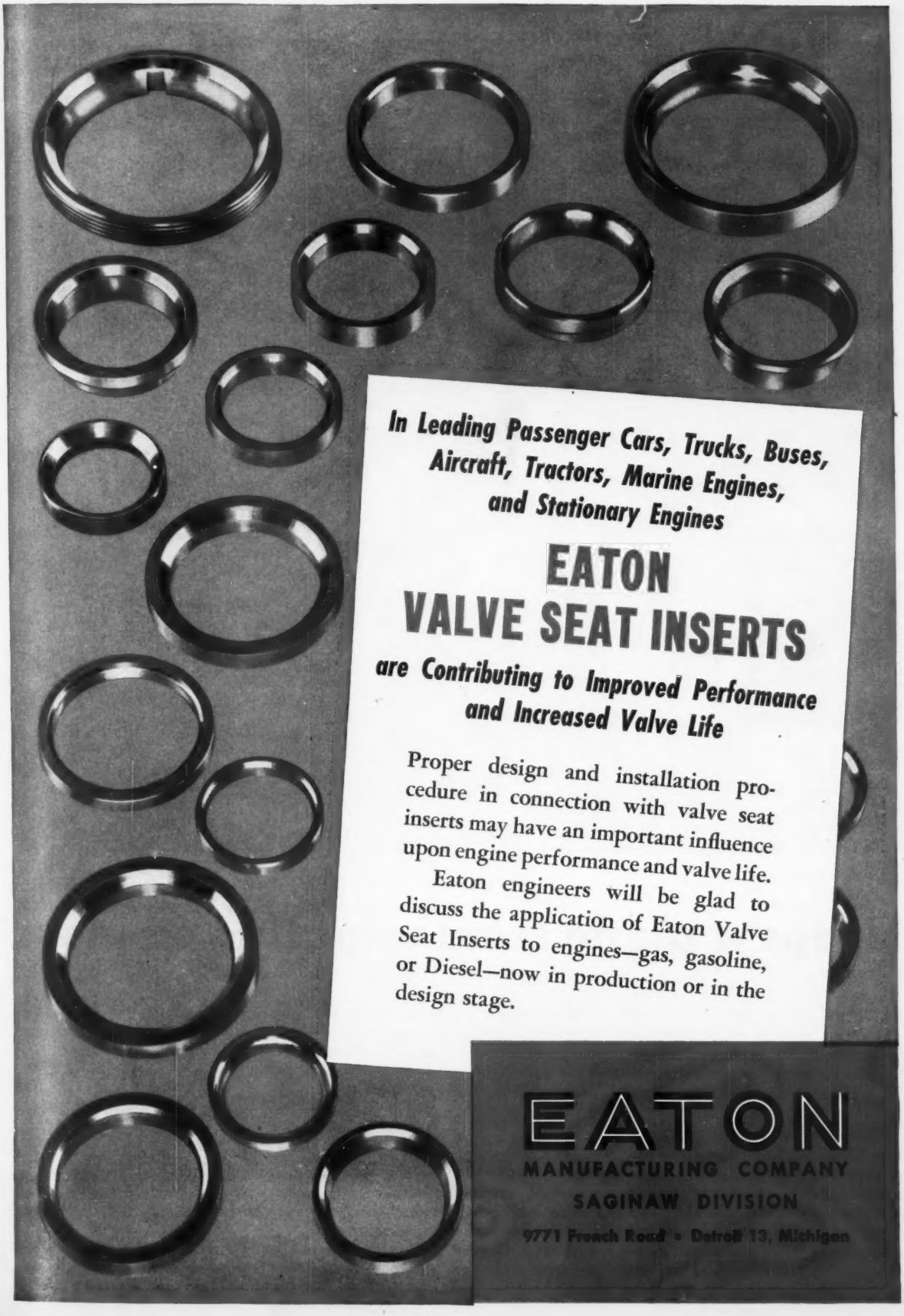
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Aerodynamics (2)

AERODYNAMIC LOADS

Effect of Yaw at Supersonic Speeds on Theoretical Aerodynamic Coefficients of Thin Pointed Wings With Several Types of Trailing Edge. W. E. Moeckel. *U.S., N.A.C.A., Technical Note No. 1549*, March, 1948. 26 pp., diagrs. 2 references.

Although the lift coefficient of a pointed wing may be increased by sweeping the trailing edges back from the center line, the variation of center of pressure and rolling moment with yaw angle is thereby increased. The variation of center of pressure and rolling moment with yaw angle is decreased when the trailing edges are swept back from the outer tips of the wing. The chordwise distance from the vertex of a symmetrical pointed wing to its center of pressure was found to be nearly independent of yaw angle when the trailing edge is swept back from the outer tips, when it is swept back from the center, and when it is swept back from both the center and the outer tips.

BOUNDARY LAYER

On the Nature of the Boundary Layer Near the Leading Edge of a Flat Plate. G. F. Carrier and C. C. Lin. *Quarterly of Applied Mathematics*, Vol. 6, No. 1, April, 1948, pp. 63–68, figs. 1 reference.

Two independent solutions were obtained for the stream function in the vicinity of the leading edge of a flat plate in incompressible viscous fluid flow. Both solutions, one of Stokes slow-flow type of solution, the other a modified Blasius solution, have a common region in which they are valid. The identical nature of the leading terms of both types of solution and the physical considerations on which the solutions are based indicate that they are at least valid asymptotic approximations, if not convergent processes.

Effects of Propellers and of Vibration on the Extent of Laminar Flow on the N.A.C.A. 27-212 Airfoil. Manley J. Hood and M. Edward Gaydos. *U.S., N.A.C.A., Advanced Confidential Report (Wartime Report No. L-784)*, October, 1939. 10 pp., illus. 5 references.

CONTROL SURFACES

Theoretical Hinge Moments for Control Surfaces in the Tail-to-Wind Case. A. R. Collar. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2210*, March, 1942. 6 pp., figs. 4 references. British Information Services, New York. $0.45.

A theoretical investigation to determine the forces acting on control surfaces when an aircraft is staked out with tail to the wind and the control column unlocked. Results for the unstalled region were in good agreement with experimental results. These experiments have indicated that the hinge moments are positive so that an unlocked surface will tend to diverge to the limit of movement and impose excessive loads on the control rods.

Wind-Tunnel Tests of the 1/9-Scale Model of the Curtiss XP-62 Airplane with Various Vertical Tail Arrangements. I. G. Racant and Arthur R. Wallace. *U.S., N.A.C.A., Memorandum Report (Wartime Report No. L-779)*, July, 1943. 121 pp., illus., figs. 3 references.

Wind-Tunnel Investigation of the Effects of Spoilers on the Characteristics of a Low-Drag Airfoil Equipped With a 0.25-Chord Slotted Flap. Ralph W. Holtzclaw. *U.S., N.A.C.A., Memorandum Report No. A5G23 (Wartime Report No. A-92)*, July, 1945. 80 pp., figs. 15 references.

Test of a 0.1475c Aileron With a Tab on Low-Drag Section for Curtiss XP-60 Airplane in the Low-Turbulence Tunnel. A. E. von Doenhoff and W. J. Underwood. *U.S. N.A.C.A., Memorandum Report (Wartime Report No. L-777)*, November, 1941. 10 pp., illus., diagrs.

FLUID MECHANICS & AERODYNAMIC THEORY

Harmonic Analysis of the Two-Dimensional Flow of an Incompressible Viscous Fluid. J. Kampé de Fériet. *Quarterly of Applied Mathematics*, Vol. 6, No. 1, April, 1948, pp. 1–13, fig. 4 references.

Two-dimensional flow of an incompressible viscous fluid in a plane, with velocity vanishing at infinity, is treated as a limiting case when the flow is within a bounded domain limited by a curve at which the velocity is zero and which will fulfill the conditions

required for the use of a Green formula. The Fourier transforms of the stream function and of the velocity components are expressed in terms of the Fourier transforms of the vorticity. The spectral function of the kinetic energy of the flow is also expressed in terms of the Fourier transform of the vorticity, thus reducing the harmonic analysis of the flow to the study of this transform. Assuming that the kinetic energy of the flow is decreasing more rapidly than an exponential function of the time, an integrodifferential equation for the Fourier transform of the vorticity is derived from the Navier-Stokes equation for the vorticity. This integrodifferential equation is the rational starting point of any rigorous study of the Fourier transform of the vorticity and hence of the spectral function. It may serve as a means of checking some working hypotheses such as the assumption that when the time is increasing the peak on the spectral surface is gradually shifted toward the high frequencies.

The Head-On Collision of a Shock Wave and a Rarefaction Wave in One Dimension. H. E. Moses. *Journal of Applied Physics*, Vol. 19, No. 4, April, 1948, pp. 383–387. 2 references.

A detailed description of the interaction between shock and rarefaction waves. The method of analysis assumes that the entropy jump across the shock is small enough to be negligible as an idealization of the process that takes place in the intermittent jet engine and in supersonic wind tunnels that obtain the air flow by permitting the outside air to enter an evacuated chamber. The position, velocity, and strength of the shock, and the velocity of the fluid, are determined as functions of time for three types of shocks: infinitesimal shocks, weak shocks, and moderately strong shocks.

On Third-Order Correlation and Vorticity in Isotropic Turbulence. F. N. Frenkiel. *Quarterly of Applied Mathematics*, Vol. 6, No. 1, April, 1948, pp. 86–90. 4 references. A study of isotropic turbulence at "large" Reynolds Number of turbulence in which the constant originally established by Batchelor and Townsend to be 30/7 is found to be 51/14.

Fluid Mechanics. G. A. Hankins. *Institution of Mechanical Engineers, Proceedings*, Vol. 157, *War Emergency Issue No. 31*, 1947, pp. 277–281, figs. 1 reference.

A survey of recent contributions of the science of fluid mechanics to lubrication, to the study of fluid friction and surface roughness, the development of laminar-flow and suction-slot airfoils, and the design of the ram-jet engine.

A General Kinetic Theory of Liquids. III—Dynamical Properties. IV—Quantum Mechanics of Fluids. M. Born and H. S. Green. *Royal Society of London, Proceedings*, Series A, Vols. 190, 191, Nos. 1023, 1025, September 9, November 11, 1947, pp. 455–474; 168–181. 14, 10 references.

INTERNAL FLOW

Beitrag zur Theorie Feststehender Schaufelgitter (A Contribution to the Theory of Stationary Bucket Grids). Richard Meyer. *Zürich, Eidgenössische Technische Hochschule, Institute für Aerodynamik, Mitteilungen Nr. 11*, 1946. 100 pp., figs. 29 references. Verlag AG. Gebr. Leemann & Co., Zürich. Sw. fr. 12.–.

The method introduced by J. Ackeret for the treatment of potential flow through a plane bucket grid is generalized and applied to a three-dimensional stationary bucket grid. The comparatively rough approximation necessitated by the assumption of axially symmetrical flow is refined by the development of eigen-functions to obtain greater accuracy. When this method is developed for a rotor and no arbitrary conditions are imposed on the slope of the leading and trailing edge of the bucket, the results obtained by the velocity-triangle method need considerable correction before they correspond with actual performance. . . which accounts for the discrepancies that have to date been observed in the calculation of velocity. An exact mathematical expression for three-dimensional potential flow through a stationary bucket grid unfortunately requires so much calculation that it is of little practical value to an engineer. When theoretical results obtained with it are correlated with experimental data, those factors that are of practical importance and those that may be disregarded should be apparent. In this way the general mathematical formulation can be simplified to the point where it will be of practical value. However, in its present form the theory allows the principle characteristics of such an axial potential flow to be evaluated. The velocity field of a special vortex sheet is calculated to illustrate the basic features of the true grid effect. The new expressions for the flow which are obtained by a purely qualitative treatment are extended to exact numerical computation of the velocity field induced by the vortex sheet for tow rotors with differing numbers of buckets and different hub ratios.

The calculation of eigen-functions plays such a central role in the numerical calculations that an appendix is included which presents, in the greatest possible detail, their characteristics, their application, and the formulas and methods used in their numerical determination.

In order to introduce this modern branch of turbine theory to the engineer a considerable portion of the work is devoted to basic concepts. The formal mathematical point of view is deliberately relegated to the background for the sake of clarity and in order to throw physical relationships into the greatest possible relief.

Two-Dimensional Aerofoils and Ducts With Uniform Velocity Distribution. G. Temple and Jennifer Yarwood. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2090*, February, 1944. 17 pp., figs. British Information Services, New York. $1.15.

An investigation to determine the exact form of two-dimensional airfoils and ducts that have uniform velocity distributions over the maximum portion of their surfaces. In order to avoid the discontinuities that would exist at the leading and trailing edges if the velocities were uniform over the entire upper and lower surfaces, a short beak and tail are added to the profile, over which the velocities are equalized without any discontinuity. The calculation is completed for a symmetric duct, and it is found that the beak and tail are of negligible dimensions.

Venturi Tube With Varying Mass Flow. B. Regenscheit. (*ZWB/FB/1945*, May 19, 1944.) *U.S. N.A.C.A., Technical Memorandum No. 1191*, March, 1948. 31 pp., illus. 6 references.

Wind-tunnel tests were made on three tubes with the flow regulated by suction at the trailing edge. The mass flow through the tube could be varied over a large range. The thrust of a shrouded propeller can be increased at low forward speeds by suction at the trailing edge of the shroud.

PARASITIC COMPONENTS & INTERFERENCE

Interference Between Wing and Body at Supersonic Speeds.—Theory and Numerical Application. Carlo Ferrari. *Journal of Aeronautical Sciences*, Vol. 15, No. 6, June, 1948, pp. 317–336, diagrs. 9 references.

A theoretical analysis of the wing-body interference of a pointed-nose body of revolution with a wing. The flow is assumed to be nonrotational, supersonic, and, at infinity, to be uniform at small angles of attack with respect to both the axis of the body and the chord of the wing. The flow is also assumed to be parallel to the plan of symmetry of the wing-body configuration. All perturbations of the uniform stream are assumed to be small in order to permit the use of the linearized equations of motion. The wing profile is assumed to be a flat plate. Two effects are analyzed: (1) the interference of the wing on the streamlined body if the induced field generated by the wing were that which would exist around the wing if it were placed in the uniform stream alone and (2) the interference of the body on the wing, neglecting the distortion of the field around the body caused by the presence of the wing. A numerical example is worked out which shows that when the lift increments are compared, the interference effect of the wing upon the body is about half as great as the effect of the body upon the wing, but that the moment increment on the body is nearly two and a half times as large as the increment experienced by the wing. The calculations are also extended to determine the optimum angle of wing setting for least drag.

PERFORMANCE

Range Performance of Turbojet Airplanes. Irving L. Ashkenas. **Letter to the Editor.** Elliot G. Reid. *Journal of the Aeronautical Sciences*, Vol. 15, No. 6, June, 1948, pp. 341, 342, figs.

A comparison of the relative values of the maximum ranges that would be realized under the conditions assumed in the original paper (by cruising at a fixed altitude, in the troposphere, and in the stratosphere) shows small deviations. The accuracy of turbojet range prediction is negligibly, if at all, improved by taking into consideration flight conditions that differ from the one yielding maximum range at fixed height. It is evident, therefore, that the fundamental aerodynamic criterion for the design of long-range turbojet aircraft is the minimization of the ratio of the drag coefficient to the square root of the lift coefficient.

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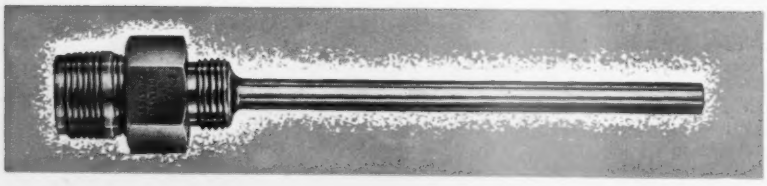

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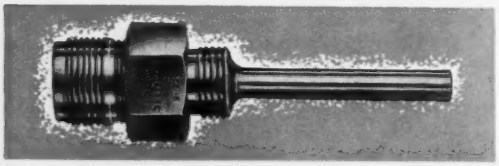

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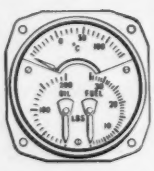

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STABILITY & CONTROL

Flying Qualities of a Twin-Engine Patrol Airplane as Estimated From Wind-Tunnel Tests. Victor I. Stevens, Jr., and George B. McCullough. *U.S., N.A.C.A., Memorandum Report (Wartime Report No. A-93)*, October, 1943. 87 pp., figs. 6 references.

Wind-Tunnel Tests of the 0.15-Scale Powered Model of the Fleetwings XBTK-1 Airplane; Longitudinal Stability and Control. Joseph Weil and Rebecca I. Boykin. *U.S., N.A.C.A., Memorandum Report No. L5D27a (Wartime Report No. L-785)*, May, 1945. 74 pp., illus. 4 references.

Wind-Tunnel of the 0.15-Scale Powered Model of the Fleetwings XBTK-1 Airplane: Lateral Stability and Control. Kenneth W. Goodson and H. Norman Silvers. *U.S., N.A.C.A., Memorandum Report No. L5F20 (Wartime Report No. L-786)*, July, 1945. 92 pp., illus., diagrs. 3 references.

Wind-Tunnel Tests of the 1/8-Scale Powered Model of the Curtiss XBTC-2 Airplane. I—Preliminary Investigation of Longitudinal Stability. Joseph Weil and Evalyn G. Wells. **II—Preliminary Investigation of Lateral Stability and Control.** Arthur R. Wallace. *U.S., N.A.C.A., Memorandum Reports (Wartime Reports Nos. L-667, L-787)*, June, August, 1944. 135; 111 pp.; illus., diagrs. 1, 6 references.

WINGS & AIRFOILS

Harmonic and Transient Motion of a Swept Wing in Supersonic Flow. John W. Miles. *Journal of the Aeronautical Sciences*, Vol. 15, No. 6, June, 1948, pp. 343–346, 370, figs. 10 references.

A study of the harmonic and transient motion and loading of two-dimensional airfoils in supersonic flow in which the component of the flow normal to the leading edge remains supersonic. The effective Mach Number is shown to correspond to the components of flow normal to the leading edge, and the various normal force derivatives are reduced by the cosine of the sweepback angle. The results are obtained by applying Busemann's rule for compressibility effects and by considering the fact that the magnitude of circulation under sweepback introduces additional aerodynamic coupling between the torsion and the bending. An approximate treatment is suggested for the flutter of a supersonic swept wing with a subsonic leading edge.

Stability of an Oscillating Airfoil in Supersonic Airflow. M. V. Barton. *Journal of the Aeronautical Sciences*, Vol. 15, No. 6, June, 1948, pp. 371–376, figs., tables. 9 references.

The stability of a two-dimensional airfoil oscillating harmonically with two degrees of freedom in supersonic flow is expressed in terms of the position of the axis of rotation of the airfoil, the reduced frequency, the ratio of the torsional and flexural modes of oscillation, and the phase angle between the modes. Evaluations are tabulated for Mach Numbers ranging from 1.2 to 2.0 and for reduced frequencies from 0.1 to 2.0. The range of Mach Numbers and of reduced frequencies is indicated in which a system with two degrees of freedom is unstable. Instability for a single degree of torsional motion does not occur at Mach Numbers greater than 1.58. The discussion includes the effect of the pivot position on stability for the various phase angles and amplitude ratios of the two modes. The tables supplement figures previously published for other Mach Numbers and reduced frequencies.

Variation of Profile Drag With Incidence. H. B. Squire. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2239*, January, 1946. 2 pp., figs. 1 reference. British Information Services, New York. $0.35.

Calculations of the profile drag of N.A.C.A. airfoils 2409, 2415, and 2421 were made by the method of Squire and Young for lift coefficients of 0.2, 0.5, and 0.8 at Reynolds Number 10^7, and with transition to turbulent flow at 5 per cent chord from the stagnation point measured along the arc on both upper and lower surfaces. The rate of increase of profile drag with incidence was assumed to be proportional to the profile drag at low incidence. The drag did not rise rapidly with increase of incidence, but the proportion of the drag associated with the upper surface did increase rapidly, amounting to about three-quarters of the total at a lift coefficient of 0.8.

Tests on NACA 0012 With Various Thick Trailing Edges at High Speeds. R. F. Sargent. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2209*, November, 1942. 5 pp., table, figs. British Information Services, New York. $0.45.

No regular variation of drag coefficient with trailing-edge thickness was found below the critical Mach Number. All modified trailing edges, however, exhibited a higher drag than the unmodified ones. Above the critical Mach Number the drag increased more systematically. M increased 0.025 for a change in trailing-edge thickness from 0.1 to 2.0 per cent of the chord.

Aerodynamic Forces on a Slotted Flat Plate. Edmund Pinney. *Quarterly of Applied Mathematics*, Vol. 6, No. 1, April, 1948, pp. 81–83.

Derivation of the theorem: A flat plate airfoil slotted symmetrically about its centerline has the same steady-state aerodynamic lift and moment as an unslotted flat plate of chord equal to the total chord of the slotted plate minus the total width of the slots.

Estimation of Critical Speeds of Airfoils and Streamline Bodies. Russell G. Robinson and Ray H. Wright. *U.S., N.A.C.A., Advance Confidential Report (Wartime Report No. L-781)*, March, 1940. 39 pp., figs. 31 references.

Preliminary Drag Tests in Flight of Low-Drag Wing on the Curtiss XP-60 Airplane. Eastman N. Jacobs. *U.S., N.A.C.A., Memorandum Report (Wartime Report No. L-745)*, December, 1941. 6 pp., illus.

Air Power (43)

Aviation Data. *Automotive Industries*, Vol. 98, No. 5, March 15, 1948, pp. 124–128, 176, 177, diagrs., tables.

Statistics on U.S. aircraft production, 1919–1947; shipments of aircraft and parts, 1946–1947; employment in 1947; certified aircraft, 1937–1947; airports, 1936–1947; domestic air lines, 1933–1947; aeronautic exports, 1912–1947; registered civil aircraft by major manufacturers; and civil aircraft by horsepower classifications.

Congress' Air Policy Board Submits 92 Recommendations. *CAA Journal*, Vol. 9, No. 4, April 15, 1948, pp. 37, 40, 41, 42.

American Air Power. *The Aeroplane Spotter*, Vol. 9, No. 207, February 21, 1948, pp. 42, 43, illus. Lists of U.S. Air Force aircraft—operational out of production, operational in production, experimental, and in production not yet in service. Prepared by the A.I.A.A.

Orders are Coming for Aircraft Industry. Robert Hotz. *Aviation Week*, Vol. 48, No. 16, April 19, 1948, pp. 11, 12, illus. With table of the Revised Budget of the National Military Establishment for the fiscal year 1948–49.

The Naval Aviation Program. Alfred M. Pride. *Aero Digest*, Vol. 56, No. 3, March, 1948, pp. 55, 57, illus. Includes a table of specifications and performance of 17 aircraft.

Air Force Procurement Problems. H. A. Shepard. *Aero Digest*, Vol. 56, No. 3, March, 1948, pp. 51, 53, illus. Specifications and performance of 23 aircraft are tabulated.

The Engineering Outlook.—The Aircraft Industry. *Engineering*, Vol. 165, No. 4284, March 5, 1948, pp. 232–235, tables.

General survey of the condition of the British aircraft manufacturing and transport industry for 1947. Major problems are analyzed and data on labor, output, development, and export are summarized. The exports of complete aircraft from the United Kingdom and from the United States are tabulated by country of destination. Brief résumé is given of the status of the American, French, Swedish, and Danish industries.

The Air Estimates. *Flight*, Vol. 53, No. 2045, March 4, 1948, pp. 268, 269, tables. An itemized summary of the Royal Air Force budget for 1948–1949 showing number and kind of personnel and distribution of expenses.

The White Paper on Defence. *The Aeroplane*, Vol. 74, No. 1916, February 27, 1948, p. 241, tables.

The Higher Direction of War. Sir Robert Sandby. *The Aeroplane*, Vol. 74, No. 1915, February 20, 1948, pp. 210, 211, illus. (Summary of paper.)

Die Fliegerei in Dänemark (Flying in Denmark). Per Weishaupt. *Schweizer Aero-Revue*, Vol. 23, No. 1, January, 1948, pp. 10–12, 22, 23, illus., diagrs.

Aviation Survey—1948: Czechslovakia. *The Aeroplane Spotter*, Vol. 9, No. 209, March, 20, 1948, pp. 66–69, illus., table.

Reorganization of the industry under nationalization and foreign activities since 1945. The principal manufacturers, their location, and the aircraft produced are listed. In addition to a brief history of the industry, a table shows the category, power plants, dimensions, gross weight, speeds, and range for 50 aircraft. Standard markings and designations indicated.

Aviation in Czechoslovakia, I, II. *The Aeroplane*, Vol. 74, Nos. 1914, 1915, February 13, 20, 1948, pp. 191–193, 217, 218, illus. Includes figures on production during the German occupation, an outline of the postwar industrial structure, and a survey of present educational and research facilities.

Malayan Aviation in the Making. *Flight*, Vol. 53, No. 2049, April 1, 1948, pp. 362, 363, illus., map.

Yokosuka Naval Air Base and Japanese Naval Aviation. C. Ray Stokes and Tad Darling. *U.S., Naval Institute, Proceedings*, Vol. 74, No. 541, March, 1948, pp. 338–343, illus.

Airplane Design & Description (10)

Choice of Fin Area and Dihedral. F. B. Baker. *Aircraft Engineering*, Vol. 20, No. 229, March, 1948, pp. 87, 88.

A mathematical exposition of the working rules used to select n_r and -1_r for a new airplane. The low-speed rate of roll and the damping of lateral oscillation rate are used as criteria and $33^1/_2$ per cent is taken as the fin and rudder safety margin.

Cockpit Confusion. . . A Challenge. George W. Hoover. *Aviation Week*, Vol. 48, No. 19, March 29, 1948, pp. 18, 21, 22, diagrs.

A large percentage of the cases of pilot error which have led to accidents can be attributed ultimately to pilot fatigue caused by the intense mental and physical activity required of him during flight and to the unhandy arrangement of flight controls. Both of these causes could be minimized by a layout in which the instruments and controls were grouped functionally and by sequence of operation. Under each of these groupings the elements could be further segregated into those that are inseparable and separable within the group. The shape of the control should also be such that it can be readily identified by sight or touch, the position of switches and controls should correspond to their setting, and instruments should give direct indications that require no interpretation by the pilot.

Next Step—The Pod. Jacob L. Devers. *The Pegasus*, Vol. 11, No. 4, April, 1948, pp. 1–3, illus.

Aircraft with detachable cargo compartments would virtually triple the transport efficiency of a cargo fleet. In addition to its commercial value this development would be of great importance in solving the supply problems of air-borne military operations.

Convertaplane, Key to Speed Range. *Aviation Week*, Vol. 48, No. 15, April 12, 1948, pp. 24–26. A description of six possible configurations that might be developed into aircraft with the hovering characteristics, speed, and maneuverability of fixed-wing aircraft.

Some American Design Problems. D. B. Hudson. *Aircraft* (Melbourne), Vol. 26, No. 5, February, 1948, pp. 17, 34.

A survey of American trends in the design of new types of aircraft, comfortization, and safety. The chief factors determining these trends are the Civil Air Regulations, the interests of the air-line operators, and the preferences of the passengers.

Aircraft and the Airlines—A Canadian View. James T. Bain. *Royal Aeronautical Society, Journal*, Vol. 52, No. 448, April, 1948, pp. 193–204.

The use and development of air-line aircraft, regularity in flight operations, safety, speed, cargo and passenger handling, and weight control in manufacture. The present financial problems of the air transport industry are to be attributed to lack of schedule regularity. This in turn is caused by the inadequacy of current aircraft designs and present airport facilities.

An Engineering Omission That Cost $16,000,000 and 52 Lives. Robert McLarren. *Automotive Industries*, Vol. 98, No. 6, April 1, 1948, pp. 37, 68, 70. The causes of the in-flight fires aboard the DC-6 and a list of the principal modifications recommended to correct the condition.

European Landing Gear Developments. H. G. Conway. *Preprint, S.A.E. Aeronautic and Air Transport Meeting*, New York, April 13–15, 1948. 33 pp., illus., diagrs.

A detailed survey of the features of English and European landing-gear design practice, hydraulic and pneumatic system design, and shock absorber design which differ from current American practice. Outside America, welding has not found the same acceptance primarily because of a lack of weldable materials with equivalent structural strength. American practice tends to specify the characteristics of the elements of an assembly which are installed by the aircraft manufacturer. On the other hand, in Europe and England reliance is placed on specialists who, acting as subcontractors, manufacture and install the assemblies. In spite of the recent appearance of 4-wheel bogies and bicycle and tandem landing gear the eventual solution to the problem may well be the substitution of skids and specially designed landing areas for the conventional landing gear. The paper also discusses tire and brake design, shock absorber retraction, and the design of hydraulic and pneumatic systems.

Disc Brakes for Aircraft. R. Waring-Brown. *Aircraft Engineering*, Vol. 20, No. 229, March, 1948, pp. 89, 90, diagrs.

The disadvantages inherent in the shoe and drum type of brake can be overcome only at an impractical weight penalty. The multiple-disc brake exemplified by the Sikorsky and the Goodyear designs avoid these undesirable features and provide greater energy absorption and less weight per unit volume. The single-disc brake has the advantages of the multiple-disc brake and also improved heat dissipation characteristics.

Chronicles of Jet Propulsion. VI—Germany (Continued). VII—Japan. *The Aeroplane Spotter*, Vol. 9, Nos. 209, 210, March 20, April 3, 1948, pp. 70; 82; illus.

American Civil Aircraft. *Western Flying*, Vol. 28, No. 4, April, 1948, pp. 9–20, 22, 24, 26, 27, illus., diagrs.

American Military Aircraft. *Western Flying*, Vol. 28, No. 4, April, 1948, pp. 28–34, 36, 38, 40, 42, 44, 46, 48, 50, illus., diagrs.

Specifications of Civil Aircraft in Use. *Western Flying*, Vol. 28, No. 4, April, 1948, pp. 60–63. 183 aircraft.

New Shapes in the Air: The Boeing B-50 Superfortress and the Fairchild C-119 Packet. *The Aeroplane Spotter*, Vol. 9, No. 209, March 20, 1948, p. 65, illus.

New Shapes in the Air: The Grumman XJR2F-1 Albatross and the Short SA-6 Sealand. *The Aeroplane Spotter*, Vol. 9, No. 210, April 3, 1948, p. 77, illus.

Aircraft of the British Air Forces of Occupation. *The Aeroplane Spotter*, Vol. 9, No. 210, April 3, 1948, pp. 78, 79, illus.

Canadian Aviation's Annual Directory of Lightplanes. *Canadian Aviation*, Vol. 21, No. 4, April, 1948, pp. 31–34, 37, 38, 40, 42, 44, 46, 48, illus.

Two Decades of Aircraft Building in Canada. *Aircraft and Airport*, Vol. 10, No. 3, March, 1948, pp. 12–14, 16, 18, 21, 22, 24, 26, 28, illus. A history of de Havilland Aircraft of Canada, Ltd.

Russian Jet Fighters Operational; Details Uncovered on YAK and Twin-Engine MIG Point Toward Well-Designed Aircraft of Good Performance. Frederick R. Brewster. *Aviation Week*, Vol. 48, No. 16, April 19, 1948, p. 15, illus.

Athena Advanced Trainer: Details of the (Avro) M K I Design With Mamba Airscrew-Turbine. *Flight*, Vol. 53, No. 2050, April 8, 1948, pp. 383–388, illus., cutaway drawings.

Bristol Civil Transport Aircraft (Type 170). *Engineering*, Vol. 165, No. 4287, March 26, 1948, pp. 297, 298, 300, illus.

Close-Up of Convair Car. *Aviation Week*, Vol. 48, No. 16, April 19, 1948, p. 21, illus.

On the Air Routes. VI—Douglas DC-6. *The Aeroplane Spotter*, Vol. 9, No. 210, April 3, 1948, p. 81, illus., diagrs.

American's DC-6 Modifications. *Airports and Air Carriers*, Vol. 13, No. 4, April, 1948, p. 23, illus.

The Durand "Pusher." Temple W. Neumann. *Nebraska Blue Print*, Vol. 42, No. 6, March, 1948, pp. 142, 143, 152, illus.

The design and preliminary testing of a three-passenger, low-wing, all-metal, pusher monoplane powered by an 85-hp. Continental four-cylinder, horizontally opposed, air-cooled engine. The wings are washed in to give good stalling characteristics.

Meteor Miscellany; Initial Trials of (Gloster) Mk VII Trainer: Recent Fighter Developments. *Flight*, Vol. 29, No. 2049, April 1, 1948, pp. 349–351, illus.

Album of Design Detail: Lockheed XR60-1 Constitution. *Aviation Week*, Vol. 48, No. 14, April 5, 1948, p. 26, illus. Outer wing panel and segmented flaps.

New Constellation Drag Strut. *Airports and Air Carriers*, Vol. 13, No. 4, April, 1948, p. 28, diagrs.

Development of the Lockheed Shooting Star. Clarence L. Johnson. *Aircraft Engineering*, Vol. 20, No. 229, March, 1948, pp. 75–78, 83–86, illus.

Super Spook. *Naval Aviation News (Reserve Edition)*, No. 12, April, 1948, pp. 1–5, illus. Design and armament of the McDonnell XF2H-1 Banshee.

German Aircraft in Detail. XVI—The Messerschmitt P. 1101. *The Aeroplane Spotter*, Vol. 9, No. 210, April 3, 1948, p. 80, illus.

The Satellite Takes Shape (Planet All-Magnesium Single-Engine 5-Seat Aircraft). *The Aeroplane*, Vol. 74, No. 1922, April 9, 1948, pp. 415, 416, illus., diagrs.

Fitting the TG-180 Turbojet to the P-84 Thunderjet. R. R. Higginbotham. *SAE Journal*, Vol. 56, No. 1, January, 1948, pp. 53–57, illus. (Extended summary of a paper: Engine Installation Problems in the XP-84 Airplane.)

New Version of the SAAB Scandia (90B). *Shell Aviation News*, No. 117, March, 1948, p. 23, illus.

Airports & Airways (39)

Airport Terminal Design. I. Walter Prokosch. *Airports and Air Carriers*, Vol. 13, No. 4, April, 1948, pp. 20, 21, illus., tables.

An analysis of the factors that determine the number of plane parking positions required at an airport terminal. The predicted estimate of daily traffic is based on the number of international, trunk, and feeder air lines using the facilities and their estimated total through originating, and terminating operations. By using the present-day time required for each operation and assuming the peak hour traffic to be 20 per cent of the daily total, the necessary number of positions can be calculated.

The Minimum Airport Runway Layout. I. M. W. Cochran. *Airports and Air Carriers*, Vol. 13, No. 4, April, 1948, pp. 8–11, figs.

The planning of the new municipal airport of Toledo, Ohio, illustrates a method of laying out runways which requires a minimum acquisition of land by the city. A study of wind direction and velocity and of ceiling and visibility showed that a single runway in the NE-SW direction could be utilized 99 per cent of the time with the velocity of the cross-wind component under 25 m.p.h. When this component is above 25 m.p.h., a secondary runway at a right angle to the primary could be used and its cross-wind component would not exceed 20 m.p.h.

Air-Traffic Co-Ordination. *Aeronautics*, Vol. 18, No. 5, April, 1948, p. 51, diagr.

A provisional traffic-control system to reduce the risk of aircraft collisions in flight during bad weather and at night. Five Flight Information Regions have been set up in the United Kingdom. The traffic control center in each region, in addition to transmitting information on weather, air hazards, and changes in navigation facilities, will maintain contact with aircraft and receive regularly transmitted intelligence as to the location and conditions of flight of all aircraft within preestablished Control Areas.

Progress at Schiphol; Further Expansion of Amsterdam Airport; Impressive Record for 1947. *Modern Transport*, Vol. 59, No. 1512, March 20, 1948, p. 9, illus., table.

Charleston High Intensity Lighting. *Airports and Air Carriers*, Vol. 13, No. 4, April, 1948, pp. 12, 13, diagr., illus.

How to Build a Seabee Dock. Jerry Leichter. *Airports and Air Carriers*, Vol. 13, No. 4, April, 1948, pp. 40, 41, illus., diagrs.

All-Weather Flying (31)

All Weather Flying. D. L. Boone. *Airports and Air Carriers*, Vol. 13, No. 4, April, 1948, pp. 19, 49, illus.

Experience of the A.F. All Weather Flying Division has shown that schedule regularity can be obtained only by operating the aircraft beyond the designer's performance limits and using highly sensitive and expensive equipment. Blind flying, in practice, requires visual contact with the runway during landing. High-intensity lighting is an important visual aid to the pilot landing at night or in bad weather, but as yet there is no provision for distinguishing the airport lights from the other lights that surround them in congested areas.

Comfortization (23)

Research Toward Seating Comfort. Kenneth R. Jackman. *Aeronautical Engineering Review*, Vol. 7, No. 6, June, 1948, pp. 16–23, illus., diagrs. 34 references.

The weight factor in aircraft seats made it necessary to conduct extensive research to develop a design for aircraft seats in which a minimum compromise would be made with the passenger's comfort. Consolidated Vultee Aircraft Corporation, in designing the Convair Liner fiberglass double seat, not only drew on the statistical and anthropological studies that had served as the basis for similar developments in other branches of the transportation industry, but also developed a standardized "buttock form" and specialized testing devices. A single and multiple indentor measured cushion deflection accurately. The "Vibrindex" picked up and recorded frequencies as low as 54 cycles per min. which are frequently a source of annoyance to passengers, and the "Ridometer" provided a 5-component photographic record of the roll, pitch, and bounce of a vehicle with timing and sequence. The chair finally developed weighed 50 lbs. and the cushions 5.2 lbs.

Designing to Reduce Airplane Noise. Based on papers by W. E. Burnham, H. L. Ericson, and J. M. Picton. *SAE Journal*, Vol. 56, No. 2, February, 1948, pp. 47–50, figs.

Boeing B-50 Induction System Pressurizes Air for Cabin. *Automotive Industries*, Vol. 98, No. 6, April 1, 1948, pp. 44, 45, 70, illus.

Description of the ducting. The unit supplies not only air for combustion to the engine, but also provides for cooling the power plant, ventilation of the nacelle, and the supercharging of air for the cabin.

Electronics (3)

Electronics and Space-Flight. Arthur C. Clarke. *British Interplanetary Society, Journal*, Vol. 7, No. 2, March, 1948, pp. 49–69, figs. 14 references.

A discussion of the power supply, antenna array, radiation frequency, and basic electronic circuits that would be required for the communication, control, and telemetering systems of space ships. The elements of an Earth-ship, planet-planet, ship-ship, and a beacon circuit; the importance of Doppler and displacement effects; and the use of radar for telemetering, prelanding surveying, meteor detection, and navigational aid are discussed.

The APS-42 Radar. L. W. Mallach. *Radio News*, Vol. 39, No. 4, April, 1948, pp. 44, 45, 178, illus.

Design and operational features of an X-band navigational radar developed from the APS-10. The transmitter-receiver and the gyro-stabilized antenna are contained in a single housing. The indicator, a 7-in. cathode-ray tube, uses a PPI type of display. The installation, designed by the Houston Corporation, provides facilities for radar mapping, responder-beacon operations, obstacle detection, and weather mapping.

Multichannel Data Recorder System. *Cook Research Laboratories*, January, 1948. 8 pp., illus.

Description and specifications of a seven-channel magnetic tape recorder developed by the Cook Research Laboratories to record and interpret phenomena such as those occurring in parachutes, rockets, and other air-borne units. The instrument will record data that has been converted to an electrical frequency with an accuracy of 2 per cent under ambient conditions of shock accelerations up to 75 g. The basic design of the instrument provides a full-scale meter deflection from an input of either 20 millivolts a.c. or 1 volt d.c. One of the seven channels in the play-back head receives a constant-frequency signal impressed on the tape which serves as a time reference and compensates for noise and variations in tape speed during recording and playback. The separate play-back unit can provide a graphic or an oscilloscope display.

German Automatic Tuning Devices. I—The German FuG-16ZY. K. P. Holcomb and J. S. Summerhayes. *U.S., Air Force, Air Technical Intelligence, Technical Data Digest*, Vol. 13, No. 9, May, 1948, pp. 7–12, illus.

The design, construction, and operation of the fine-tuning control developed for the FuG-16, the standard German VHF radiotelephone aircraft equipment. Rough tuning was accomplished by the FuG-16ZY, a four-channel preset automatic tuner. Cams mounted on a rotating drum selectively engaged start-stop switches until the switch with which the remote-control selector switch is energizing the tuning drive motor is engaged. The remote tuning of the FuG-220 air-interception radar equipment was accomplished by identical transmitter and slave Selsyn units. Each unit contained a single armature winding and three field windings in the conventional star connection.

A Flat-Response Single-Tuned I. F. Amplifier. E. H. B. Bartelink, J. Kahnke, and R. L. Watters. *Institute of Radio Engineers, Proceedings*, Vol. 36, No. 4, April, 1948, pp. 474–478, illus., diagrs. 1 reference.

An intermediate-frequency amplifier providing double-tuned response using single-tuned circuits with negative feedback.

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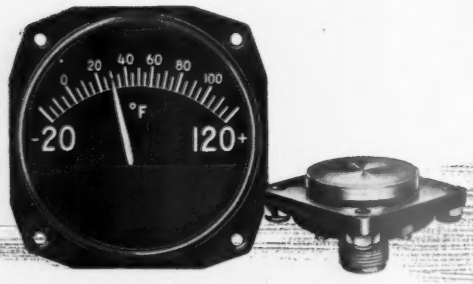

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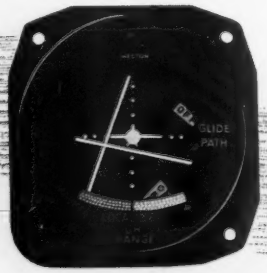

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Particular attention is centered on the problems arising in the case where relatively narrow pass bands are wanted.

Communication Control Equipment. *The Log*, Vol. 8, No. 3, March, 1948, pp. 58–63, illus.

A description of the components of two intercommunication systems, type 17 for larger aircraft and type 46 for smaller aircraft, developed by Ultra Electric, Ltd. Both installations enable any crew member to select at will any of the radio facilities available in the aircraft.

The Duct Capacitor. Alan Watton. *Institute of Radio Engineers, Proceedings*, Vol. 36, No. 4, April, 1948, *Waves and Electron Section*, pp. 550–554, diagrs. 10 references.

Design, construction, and characteristics of a feed-through capacitor with an insertion loss that rises indefinitely with the frequency. The conductor is surrounded by concentric foil cylinders separated by dielectric layers. Alternate cylinders form the elements of the capacitor. One element is soldered to the conductor, the other to the metal case of the unit. The case is affixed to the inside wall of a metal housing that completely shields either a noise source, a motor, or a radio receiver, and the conductor of the capacitor forms an element in the input of the installation. Because of its negligible external magnetic field, the duct capacitor makes possible the construction of filters having high attenuation at higher frequencies where ordinarily the existence of appreciable interaction between the filter elements limits the maximum obtainable attenuation.

An Electronic Switch With Variable Commutating Frequency. E. E. Carpentier. *Philips Technical Review*, Vol. 9, No. 11, 1947–1948, pp. 340–346, diagrs.

The normal oscillograph amplifier which led to distortion of the commutating voltage is no longer used. This permits the commutating frequency to be raised to 40,000 cycles per sec. The input may be asymmetrical or symmetrical. More than two oscillograms may be produced simultaneously by using the electronic switches in cascade.

Metallized Circuits. John T. Collier. *Product Engineering*, Vol. 19, No. 4, April, 1948, pp. 141–143, illus. Production techniques used in the manufacture of inlayed metal electric conductor systems to replace conventional wiring in radios.

Meteorological Radio Direction Finding for Measurement of Upper Winds. Robert A. Kingman and John M. LeBedda. *Journal of Meteorology*, Vol. 5, No. 1, February, 1948, pp. 28–37, illus. 4 references.

A summary of the development of radar and radio-direction finders for the determination of wind direction and velocity. The SCR-658, a single unit for both tracking and receiving sonde data, is limited by operator's error in matching two pairs of pips on an oscilloscope screen and it cannot provide accurate wind velocity data at elevations less than 14°. The radio set AN/CRD-1 now under development will incorporate automatic tracking and increase the operating frequency from 400 to 1,725 megacycles. It is expected to have a dynamic error of 0.03° to 0.05°.

Magnetoionic Multiple Refraction at High Latitudes. S. L. Seaton. *Institute of Radio Engineers, Proceedings*, Vol. 36, No. 4, April, 1948, pp. 450–454, illus. 9 references.

The theories of Appleton and Builder indicate the possibility of multiple refraction of ionosphere soundings that will yield rays, either longitudinal or transverse, of the ordinary and extraordinary type and, when there is an appreciable frequency of collision of free electrons with neutral air particles, a second ray of the extraordinary type. The observations of Scott and Davies at high northern latitudes have verified this triple refraction and identified two of the rays as the ordinary and the extraordinary ray. The third they designated the Z component. Observations made at the College Geophysical Observatory, University of Alaska, 64° N. Lat., identified the Z component as the second extraordinary ray of the transverse mode of propagation. Since one of the factors determining the refraction of electromagnetic waves is the ratio of the natural angular frequency of gyration of free electrons about the longitudinal and the transverse components of the Earth's magnetic field, multiplied by the frequency of collision, or friction, of free electrons with neutral air particles, the critical value of the friction factor becomes smaller as the poles are approached. At some point in high geomagnetic latitudes the critical value of the friction factor probably coincides with its value for the atmosphere. The frequency of collision of electrons with neutral air particles at 300 km. altitude and in the geomagnetic latitude of Fairbanks, Alaska, is calculated to be in the vicinity of $4(10)^4$.

Engineering Practices & Aids (49)

Airframe Drawings. Edmund W. Coates. *Aeronautics*, Vol. 18, No. 5, April, 1948, pp. 34–36, diagrs. A system of positioning details on structural drawings which eliminates some of the confusion and obscurities of the current drafting conventions by adopting the legends used by cartographers.

Decimal Dimensioning Conversion Painless for Aeronautic Industry. O. E. Kirchner. *SAE Journal*, Vol. 56, No. 1, January, 1948, pp. 47–49. 1 reference. (Extended summary of a paper: Decimal Dimensioning—What Profit?)

The Preparation of Instructional and Servicing Handbooks. David Vine. *The Engineer*, Vol. 185, No. 4808, March 19, 1948, pp. 274, 275.

A Study of Patent Policies in Educational Institutions, Giving Specific Attention to the Massachusetts Institute of Technology, I. Vincent Lee McKusick. *Franklin Institute, Journal*, Vol. 245, No. 3, March, 1948, pp. 193–225. 42 references.

Equipment

Simplicity as a Goal in the Design of Aircraft Systems. L. R. Koepnick. *Preprint, S.A.E. National Aeronautic and Air Transport Meeting*, New York, April 13–15, 1948. 9 pp.

An analysis of the number of passenger miles flown by T.W.A.'s transport aircraft per mechanical delay shows that the recent, more complex airplanes are less efficient from an operational and maintenance standpoint than the older, simpler craft. All but a small percentage of these delays were caused by failures of the aircraft accessories and systems. This high incidence of failure can be attributed to a lack of development and testing of the systems, exaggerated minimum requirements, and lack of overall planning in the allocation of space to each system. This contention is borne out by the trend among the air-line operators to replace automatic controls with manual controls, and by the unexpected success of the hydraulic system of the Lockheed Constellation which prior to installation was given thorough full-scale tests. Maintenance, and therefore operational economy, can be obtained only when the same emphasis is placed on the design of systems that is placed on the design of structures and controls and when systems are properly segregated and packaged for rapid replacement.

ELECTRICAL (16)

Metallurgical Examination of a Japanese "Zeke" Aircraft Volt Box. L. H. Grenell, J. R. Cady, F. M. Stephens, Jr., and H. W. Gillett. *Gt. Brit., British Intelligence Objectives Sub-Committee, Report No. B.I.O.S./J.A.P./P.R./1469*, August 31, 1944. 7 pp., illus., table. British Information Services, New York. $0.55.

HYDRAULIC & PNEUMATIC (20)

How to Prepare Hydraulic Assemblies for Storage; Corrosion-Preventive Hydraulic Oils Manufactured by Standard Oil Co. Recommended for Stored Hydraulic Assemblies. *Plane Facts*, Vol. 5, No. 3, March, 1948, pp. 24, 25, 32.

The Torque Converter Type "Foettinger." W. Spannhake. *U.S., Navy Dept., David Taylor Model Basin, Report No. 590*, September, 1947. 7 pp., diagrs. 1 reference.

Design, operation and characteristics of a turbomachine. A guide-vane system returns the fluid from the secondary wheel back to the primary wheel in order to avoid the conversion of kinetic energy into pressure. The constant factor in the expression for the power transmitted by the converter, which is determined by the transmission, varies but slightly when a ratio other than the optimum is used.

Split-Second Operation Claimed for Pneumatics. Howard F. Schmidt and H. F. Gerwig. *SAE Journal*, Vol. 56, No. 1, January, 1948, pp. 50–52, illus. (Extended summary of a paper: Why Pneumatics? Or the Case for Pneumatics for Intermittent Services on Aircraft.)

Flight Safety & Rescue (15)

Lightning Effects on Aircraft. M. M. Newman. *Preprint, S.A.E. National Aeronautic and Air Transport Meeting*, New York, April 13–15, 1948. 10 pp., illus., diagrs.

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Laboratory tests made with an airplane instrumented to record lightning currents and subjected to discharges ranging to 100,000 amp. showed that modern all-metal transport aircraft in general are inherently well protected from lightning damage. Certain external elements, however, such as movable control surfaces, plastic sections, and outside antennas, require protection. The complexity of lightning and related transient electrical phenomena require continuing researches directed toward the reduction of the hazards from secondary effects, such as the disabling of radio communications, and toward the standardization of protective measures.

Why Pilots Make Mistakes. Paul W. Tibbets, Jr. *Flying*, Vol. 42, No. 4, April, 1948, pp. 14, 15, 52, 54, illus.

Summary of the findings of the Aero Medical Laboratory of the Air Materiel Command at Wright Field. Instrument and control layout and design are major contributing factors in "pilot error." Greater safety could be attained by standardization of cockpits and their redesign to provide maximum display intelligibility and optimum control action.

Improvise Crash-Study Technique. Scholer Bangs. *Aviation Week*, Vol. 48, No. 14, April 5, 1948, pp. 24, 25, illus.

In order to determine the cause of the failure of the DC-6 that crashed at Bryce Canyon, Utah, in November, 1947, the wreckage was reassembled in a special jig to give a mock-up of the crashed airplane. Comparison of fragments of the wreck with new components and chemical analysis of the soot on the fragments revealed the origin of the fire that caused the crash.

CAA Reports Progress in Fire Prevention Work. Harvey L. Hansberry. *SAE Journal*, Vol. 56, No. 2, February, 1948, pp. 36, 37, illus. (Extended summary of a paper: CAA Aircraft Fire Prevention Developments.)

Senate Aviation Subcommittee Given Safety Recommendations. *Aviation Week*, Vol. 48, No. 19, March 29, 1948, p. 37. Summary of the proposals.

Flight Testing (13)

A Note on Flight Flutter Testing. Robert Rosenbaum and Robert H. Scanlan. *Journal of the Aeronautical Sciences*, Vol. 15, No. 6, June, 1948, pp. 366–370, diagrs., figs. 5 references.

A method of calculation of the theoretical decay effects of wing oscillations at subcritical flutter speeds which yields a trend curve from which the noncritical nature of flutter conditions may be judged. A partial verification of this theory has been obtained from the analysis of flight-test data which were taken after unsymmetric flutter had been excited in the wing of an aircraft traveling at a subcritical speed by an abrupt deflection and release of the ailerons.

High-Speed Flight Research. II. H. Davies. *Flight*, Vol. 53, No. 2049, April 1, 1948, pp. 364, 365, figs. (Extended summary of a paper.)

The effects of compressibility on the longitudinal characteristics of an aircraft were first observed by the large changes in trim that occurred in high-speed dives. These observations, however, could not be used to derive precise conclusions as to the stability changes that took place because in a dive the lift coefficient was, of necessity, very small. Jet-propelled aircraft have made it possible to determine both the stick-free and the stick-fixed variation in stability of aircraft with Mach Number up to 0.8.

Circular Speed. *Aeronautics*, Vol. 18, No. 5, April, 1948, pp. 46–50, illus.

A narrative description of the flights in which W. A. Waterton piloted a Gloster Meteor EE528 powered by two Rolls-Royce Derwent V turbojet engines over a close circuit course to establish a speed record of 542.94 m.p.h. and the flights over a similar course in which M. J. Lithgow clocked a record of 564.881 m.p.h. in a Vickers Supermarine Attacker TS409 powered by a Rolls-Royce Nene turbojet. Time lost in turning could be minimized if the course flown were a perfect circle, but the difficulty of setting up a sufficient number of observation points on such a course necessitates the use of a less efficient course with a limited number of turning points. The optimum turn technique employs the ordinary turn made with the aircraft on a horizontal course and at a moderate g.

Britain Highest Again; Group Capt. John Cunningham Breaks the Altitude Record in a de Havilland Ghost Vampire. *Flight*, Vol. 53, No. 2049, April 1, 1948, pp. 347, 348, illus.

Fuels & Lubricants (12)

Effect of Radiation on the Rate of Burning of Solid Fuel Rocket Propellants. S. S. Penner. *Journal of Applied Physics*, Vol. 19, No. 4, April, 1948, pp. 392–398, tables. 7 references.

The temperature rise of powder grains in different rocket motors, resulting from the absorption of radiant energy, has been computed by the method of Avery. The calculated results show that more radiant energy is absorbed by the powder grains in large service rockets than in small experimental test motors. The increase in powder temperature before burning, associated with the absorption of radiant energy, leads to an increase in the average rate of burning of the solid fuel charge. The differences in burning rate produced by the absorption of radiant energy amount to less than 4 per cent for the rocket motors commonly employed. Thus burning rate results obtained in small test motors may be applied to predict the approximate behavior of the same propellant in a large service rocket.

Detonation Properties of Fuel-Air Mixtures for Use in Reaction Propulsion. (*Braunschweig, Luftfahrtforschungsanstalt Hermann Göring, ZWB/FB/1459*, September, 1941.) G. Damkoehler and R. Edse. *U.S., Air Force, Translation No. F-TS-978-RE*, March, 1948. 45 pp., figs. 9 references.

An investigation of the detonation characteristics of "Leuna," propane, acetylene, hydrogen, ether, ethanol, and benzene fuel-air mixtures to determine their suitability as fuels for athodyds with discontinuous combustion. Only the acetylene-air mixture detonated under the test conditions. The addition of ethyl nitrate, ethyl nitrite, or ozone failed to bring about detonation, but increased the violence of the reaction where detonation had already been obtained. The detonation tendency and quality rating of the reactions obtained were rated according to empirical standards. Combustion and thrust data and experimental methods are compared with those of other researchers.

The Effect of Fuel Composition, Compression Pressure, and Fuel-Air Ratio on the Compression-Ignition Characteristics of Several Fuels. W. A. Leary, E. S. Taylor, C. F. Taylor, and J. U. Jovellanos. *U.S., N.A.C.A., Technical Note No. 1470*, March, 1948. 107 pp., illus., figs. 7 references.

Exploratory investigation to determine the variation in ignition delay and the rate of pressure rise after compression of isooctane, 100-octane gasoline, triptane, and benzene. The air-fuel ratio and the compression ratio were the only independent variables. A comparison of the detonating tendencies of two fuels was found to require a consideration not only of the length of the delay period but also an evaluation of the rate of pressure rise after compression. The excellent antidetonation properties of benzene appear to be due to the slowness of the pressure rise during combustion of the end gas rather than to an exceptionally long delay period. The resistance of triptane to detonation appears to be due to the long ignition delay as well as to a relatively slow pressure rise during combustion of the end gas.

Factors Affecting the Selection of Propellants for Rocket Powered Aircraft. Thomas F. Reinhard. *Preprint, S.A.E. National Aeronautic and Air Transport Meeting*, New York, April 13–15, 1948. 5 pp.

The specific impulse developed by a rocket fuel is directly proportional to the heat content of the fuel and is inversely proportional to its molar specific heat. While hydrogen and fluorine will provide the highest specific impulse, ease of handling, simplicity of power-plant design, the danger of poisoning in case of a leak, and the fire hazard dictate the selection of a more suitable combination. Hydrogen-nitrogen compounds, because of their low heat of formation and high density, present an attractive second choice as fuels. While gasoline itself is inefficient as a rocket fuel, petroleum products, by the substitution of NH_2 for hydrogen atoms, can be converted into amines. These compounds have a low heat of formation and could be sufficiently available to serve as a standard rocket fuel.

Evaluate Light Plane Engine Oil in Flight-Simulated Lab Tests. W. J. Backoff, N. D. Williams, K. Boldt, and J. G. Hall. *SAE Journal*, Vol. 56, No. 2, February, 1948, pp. 31, 84, illus. (Extended summary of a paper: Evaluation of Light Aircraft Engine Lubricants.)

Lead Susceptibility of Several Fuels as Determined in an Air-Cooled Aircraft-Engine Cylinder. Edward G. Stricker, Jerrold D. Wear, and Reece V. Hensley. *U.S., N.A.C.A., Restricted Bulletin No. E6A07*, February, 1946. 12 pp., figs. 2 references.

Effects of Fuel-Vapor Loss on Knock-Limited Performance and Inspection Properties of Aviation Fuels (28-R and 33R). Henry C. Barnett and Edred T. Marsch. *U.S., N.A.C.A., Restricted Bulletin No. E6C01* (*Wartime Report No. E-221*), March, 1946. 11 pp., illus., diagrs.

The Knock-Limited Performance of Fuel Blends Containing Spiropentane, Methylenecyclobutane, Di-*tert*-Butyl Ether, Methyl-*tert*-Butyl Ether, and Triptane. Carl L. Meyer. *U.S., N.A.C.A., Restricted Bulletin No. E6D22* (*Wartime Report No. E-222*), May, 1946. 5 pp., figs., tables. 2 references.

Knock-Limited Performance Tests of 2,2,3,4-Tetramethylpentane, 2,3,3,4-Tetramethylpentane, 3,4,4-Trimethyl-2-Pentene, and 2,3,4-Trimethyl-2-Pentene in Small-Scale and Full-Scale Cylinders. Edmund R. Jonash, Carl L. Meyer, and Robert J. Branstetter. *U.S., N.A.C.A., Advance Restricted Report No. E6C04* (*Wartime Report No. E-236*), March, 1946. 56 pp., figs. 5 references.

Knock-Limited Performance of Several Internal Coolants. Donald R. Bellman and John C. Evvard. *U.S., N.A.C.A., Advance Confidential Report No. 4B08* (*Wartime Report No. E-211*), February, 1944. 22 pp., figs.

The Effect of Engine Conditions on the Lead Susceptibility of Paraffinic Fuels. Henry C. Barnett and Harry S. Imming. *U.S., N.A.C.A., Advance Restricted Report No. E4J02* (*Wartime Report No. E-226*), October, 1944. 39 pp., figs. 3 references.

Lead Susceptibility of Paraffins, Cycloparaffins, and Olefins. Henry C. Barnett. *U.S., N.A.C.A., Advance Restricted Report No. 3E26* (*Wartime Report No. E-223*), May, 1943. 34 pp., figs. 2 references.

Flight and Test-Stand Investigation of High-Performance Fuels in Double-Row Radial Air-Cooled Engines. I—Determination of Cooling Characteristics of Flight Engine. Calvin C. Blackman, H. Jack White, and Philip C. Pragliola. *U.S., N.A.C.A., Memorandum Report No. E4L20* (*Wartime Report No. E-247*), December, 1944. 20 pp., illus., figs. 4 references.

Knock-Limited Blending Characteristics of Benzene, Toluene, Mixed Xylenes, and Cumene in an Air-Cooled Cylinder. Reece V. Hensley and Roland Breitwieser. *U.S., N.A.C.A., Memorandum Report No. E5B03* (*Wartime Report No. E-251*), February, 1945. 36 pp., figs. 3 references.

Comparison of the Knock-Limited Performance of Triptane With 23 Other Purified Hydrocarbons. J. Robert Branstetter. *U.S., N.A.C.A., Memorandum Report No. E5E15* (*Wartime Report No. E-259*), May, 1945. 47 pp., diagrs. 14 references.

The Knock-Limited Performance of Fuel Blends Containing Aromatics. I—Toluene, Ethylbenzene, and *p*-Xylene. Carl L. Meyer and J. Robert Branstetter. *U.S., N.A.C.A., Advance Restricted Report No. E4J05* (*Wartime Report No. E-227*), October, 1944. 52 pp., figs. 2 references.

The Knock-Limited Performance of Fuel Blends Containing Aromatics. II—Isopropylbenzene, Benzene, and *o*-Xylene. Robert Branstetter and Carl L. Meyer. *U.S., N.A.C.A., Advance Restricted Report No. E5A20* (*Wartime Report No. E-229*), January, 1945. 52 pp., figs. 2 references.

The Knock-Limited Performance of Fuel Blends Containing Aromatics. III—*1,3,5*-Trimethylbenzene, *tert*-Butylbenzene and *1,2,4*-Trimethylbenzene. Carl L. Meyer and J. Robert Branstetter. *U.S., N.A.C.A., Advance Restricted Report No. E5D16* (*Wartime Report No. E-230*), April, 1945. 49 pp., figs., tables. 3 references.

Gliders & Gliding (35)

Science—Stratospheric Research. I. R. Jarland. (*Espace* (Paris), July, 1947.) *Soaring*, Vol. 12, No. 1–2, January-February, 1948, p. 7.

For meteorological research the glider offers the advantages of low speed, adequate pay load, no vibration, and no large electrical field. Sailplanes with pressurized cabins have reached altitudes of 65,000 ft. under ideal conditions, and should without difficulty be able to reach 50,000 ft. with airplane tow or in soaring flight.

Guided Missiles (1)

Wind-Tunnel Measurements on the Henschel Missile "Zitterrochen" in Subsonic and Supersonic Velocities. Weber and Kehl. **Wind-Tunnel Measurements on the Wing of the Henschel Missile "Zitterrochen" in Subsonic and Supersonic Velocities.** Kehl. (*ZWB/UM/3122, 3161*, October 7, 24, 1944.) *U.S., N.A.C.A., Technical Memorandum No. 1159*, April, 1948. 31 pp., figs.

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An investigation of the effect of three wing forms, with aspect ratios 2.0, 1.0, and 0.5, on the aerodynamic forces and moments measured on the Zitterrochen, a controlled missile. The ratio of the lift coefficient and the ratio of the moment coefficient to the angle of attack increased with increasing Mach Numbers from 0.5 to 1.99 as the aspect ratio increased. The drag coefficient also increased, and the pressure point shifted forward with increasing aspect ratio. No significant decrease in the lift coefficient was observed as the velocity of sound was approached. The lift coefficients at supersonic velocities were of the same magnitude as those for the same angle of attack in the subsonic region. Control plates were found to be less effective at supersonic velocities than at velocities below the speed of sound.

Tests supplementing the above confirmed the decrease at supersonic speeds of the drag coefficient with increasing Mach Number, and a like decrease in the lift coefficient for a constant angle of attack. The pressure point, while farther aft in supersonic than in subsonic flow, remained independent of the Mach Number.

Stability of Automatically Controlled Guided Missiles. Stinshoff. (*ZWB/W VA/PA/45/40*, June, 1945.) *U.S., Air Force, Translation No. F-TS-2671-RE*, March, 1948. 6 pp., figs.

An outline of research projects of the Deutsche Forschungsanstalt für Segelflug, Ainring, and summary of results. Test flights confirmed the practicability of obtaining lateral stability in guided missiles with an aileron and a gimbal-supported free gyroscope with its axis tilted aft. Problems of longitudinal stability and control were investigated in collaboration with the Darmstadt Technische Hochschule. Related subjects under investigation included: gyroscope errors, hunting, and nutation; the application of on-off control to systems with one degree of freedom both with and without restoring forces and self-damping; the effect of acceleration on damping; trajectories and probability of hits. Extensive investigation was made of the control of rotating missiles and the use of a proximity-fused target seeking control during the later portion of their trajectory.

Change of Course of A-4 Rocket with Hawai II Guide Beam. Jonke. (*ZWB/PA/87/146.*) *U.S., Air Force, Translation No. F-TS-3090-RE*, March, 1948. 8 pp., figs. An investigation of the transient steering of a guided missile (A-4) into a stationary guide beam inclined at an angle of 39° to the horizontal.

History & Literature*

The Wright Brothers. *Royal Aeronautical Society, Journal*, Vol. 52, No. 447, March, 1948, pp. 141–150, illus. 11 references. A brief summary and an appreciation of the work of the Wright brothers.

Atlantic Retrospect & Prospect. J. C. Fitzmaurice. *Aeronautics*, Vol. 18, No. 5, April, 1948, pp. 23–27, table. Non-stop North-Atlantic flights from East to West.

Installations

SHIPBORNE (28)

FJ-1 Makes First Carrier Test: North American Jet Fighter Clears Deck in 700 ft. on Fly-Off Experiment. Scholer Bangs. *Aviation Week*, Vol. 48, No. 21, March 22, 1948, p. 13, illus.

H. Walter Kommanditgesellschaft. W. J. Woodward, R. R. Witter, and E. V. Dahl. *Combined Intelligence Objectives Sub-Committee, Evaluation Report No. 110*, June 15, 1945. 3 pp. British Information Services, New York. $0.10. Brief description of research projects on a catapult using peroxide-permanganate fuel, rocket fuel combustion, and mine detonation by underwater blasts.

UNDERGROUND (32)

Production Underground: Manufacture of Aircraft Equipment in London Tube Tunnels by the Plessey Co., Ltd. *Aircraft Production*, Vol. 10, No. 112, February, 1948, p. 55, illus.

Instruments (9)

Machmeters for High-Speed Flight Research. Herbert Schaeffer. *Journal of the Aeronautical Sciences*, Vol. 15, No. 6, June, 1948, pp. 351–363, illus., diagrs. 16 references.

A résumé of the theory, design, and function of Machmeters. The principle features of subsonic and supersonic flow are described to show the need for such a device as a test instrument and as a flight instrument. Both the subsonic and the supersonic Machmeters operate by indicating the difference between the stagnation and the free-stream air pressure which at supersonic speeds can be expressed by graphs that show the relations of pressure and temperature at the stagnation point with respect to the Mach Number. The discussion is extended to include two developments of the Machmeter, the Mach Number Limit Switch and the Maximum Allowable Airspeed or Mach Airspeed Indicator. One problem presented by the extension of this measuring device to supersonic speeds has been the locating of pressure vents. A new type of supersonic static pressure probe is suggested.

Analysis of Types of Errors in Reading of the Conventional Three-Pointer Altimeter. Walter F. Grether. *U.S., Air Force, Air Materiel Command, Engineering Division, Aero Medical Laboratory, Memorandum Report No. MCREXD-694-14A*, March 16, 1948. 23 pp., diagrs. 2 references.

Data obtained during actual tests show that the most common error that was made in reading the conventional three-pointer altimeter was obtaining a reading too high by one revolution of the sensitive pointer. Other errors were: combining readings from different pointers, misreading the scale, omission of a pointer, interchange of two indications or the repetition of one, and reading to the lower adjacent number rather than to the nearest figure. It is apparent that the combining of readings from two or more pointers into a single quantitative reading is a difficult mental task that offers many opportunities for error. Many of them would be eliminated by a single-pointer instrument with a counter to indicate the number of revolutions of the pointer.

The Design of Instrument Dials for Ease of Reading. Walter F. Grether. *Preprint, S.A.E. National Aeronautic and Air Transport Meeting*, New York, April 13–15, 1948. 11 pp., diagrs. 13 references.

The results of recent psychological research have shown that a group of 16 instruments with pointers aligned at 9 o'clock can be check-read in the same time it takes to check-read a single indication. The most efficient indication of instruments that read qualitatively is obtained when the motion of the indicator corresponds to the motion of the airplane. The combination of two or more pointers into a single quantitative reading is a difficult mental task. A persistent type of error was found in reading too high by one revolution of the sensitive pointer or in the displacing or interchanging of the digits in their series when read from different pointers.

Exhaust Gas Thrust Meter. Mohr. (*Hirth Motoren G.m.b.H., Versuchmitteilung VSA 1-304, He/Sup/47*, February 18, 1944.) *U.S., Air Force, Translation No. F-TS-2033-RE*, March, 1948. 16 pp., figs.

Report of tests made to determine the soundness of the design of a counterweighted baffle plate and measuring device to determine the thrust of exhaust gases. Values measured by the plate were from 5 to 8.5 per cent lower than those computed. The portion of this error attributable to the mechanics of the device was deemed removable by recalibration.

"Rate-Rate" Control. *Aircraft* (Melbourne), Vol. 26, No. 5, February, 1948, pp. 14–16, 46, illus., diagrs. The Smith S.E.P.1 automatic pilot.

The A-12 Gyropilot. P. Halpert. *Preprint, S.A.E. National Aeronautic and Air Transport Meeting*, New York, April 13–15, 1948. 24 pp., illus., diagrs. 7 references.

The Sperry Gyropilot was essentially a stabilizer maintaining the airplane's heading and attitude for moderate periods of time. The extension of its scope and the improvement of its accuracy so that automatic flight could be maintained even in turbulent air, at approach speeds, and at low indicated speeds at high altitudes required the development of new controls to cope with an increased number of aerodynamic variables. It also had to be sufficiently flexible to accommodate to the structural strength and control characteristics of different aircraft. In its present development the A-12 Gyropilot and Automatic Control Approach can maintain: attitude, magnetic heading, altitude, longitudinal trim, air speed, a navigational track, and the approach to the runway, and can establish and maintain coordinated turns. A flux valve converting the steady magnetic field of the Earth into a pulsating signal having the same directional properties continuously corrects the spin axis of the gyro to the magnetic meridian

and compensates for precession. The vertical gyro is continuously slaved to the direction to correct for deviations of the spin axis from the vertical. A number of recordings show the performance of the instrument in actual operation.

The PB-10 Automatic Pilot For Air Transport. P. A. Noxon. *Preprint, S.A.E. National Aeronautic and Air Transport Meeting*, New York, April 13–15, 1948. 10 pp., illus., diagrs.

The Pioneer PB-10 autopilot is a self-synchronous system requiring no special routine of engagement. It is provided with a quick release, and the circuit is designed to minimize the possibility of a hard-over signal being applied to the control surfaces. This possibility is further reduced by the low r.p.m. of the servomotors and their torque rating, which is set below the design load of the aircraft. The frequency band in which disturbances occur is kept to that defined by the normal control constants of the automatic pilot-airplane loop. Thus the amplitudes of the departure from datum while on automatic are less than those obtained manually. The use of a rate signal in yaw rather than a deflection signal increases the damping of the aircraft in yaw, makes wallowing unnoticeable, and accommodates for the difference in stall and lift between the wings. Normal control is kept effective to lower speeds than are possible with manual control. The output of the autopilot can be matched to the control characteristics of different aircraft and the simple series input system makes the incorporation of the PB-10 into a more comprehensive system a relatively simple matter.

Report on Aircraft Instruments, Etc., Produced by Firm Albert Pattin of Berlin and Wesben (Interrogation of Herr Rolla). W. Abson. *Combined Intelligence Objectives Sub-Committee, Evaluation Report No. 215*, July 18, 1945. 3 pp., diagr. British Information Services, New York. $0.10.

Instruments and projects under development by the firm of Albert Pattin, Berlin. A circuit diagram is given of a servo amplifier in which the armature of the drive vibrates through a small arc, clockwise or counterclockwise according to the indication received from the sensing element.

Laboratories, Aeronautical (50)

Construction of (de Havilland) Propeller Test Beds at Hatfield. *Engineering*, Vol. 165, No. 4288, April 2, 1948, pp. 332, 324, illus.

The construction techniques used in pouring the two hexagonal reinforced concrete tunnels at Hatfield, Herfordshire, England, which are to be used for testing aircraft power plants. The internal dimensions were kept to a tolerance of $^1/_8$ in.

Building the (de Havilland) Propeller Test Beds, Hatfield. *The Engineer*, Vol. 185, No. 4810, April 2, 1948, pp. 324, 325, illus.

Manufactured Weather. *Automotive Industries*, Vol. 98, No. 6, April 1, 1948, pp. 34–36, illus. N.A.C.A. Aircraft Engine Research Laboratory. Photographs of the installation and typical sections.

Gas-Turbine Development; The New Wright Laboratory; Use of Air From Compressor Tests. *Aircraft Production*, Vol. 10, No. 112, February, 1948, p. 56, illus., diagr.

Research on the Development and Propagation of Hydrodynamic Noise. Progress Report 2—Progress on the Development of Hot-Wire Methods for Velocity Measurements in Water. M. S. Macovsky. *U.S., Navy, David Taylor Model Basin, Report No. 592*, October, 1947. 6 pp., diagrs., illus. 3 references.

A review of the theory of the hot-wire anemometer and the results of attempts to use them to measure the degree of turbulence in a stream of water. Two "bread-board" hot wire instruments, one a.c., the other d.c., were used. Both were basically Dublin-shunt circuits equivalent to Wheatstone bridges. With the d.c. instrument it was impossible to repeat calibrations because of an apparently shifting zero value. The probes of the a.c. instrument acquired a coating, apparently from fine suspended matter in the water, which caused the heat conductivity of the wire to change continuously and made it impossible to repeat results.

Laws & Regulations (44)

Pennsylvania Supreme Court Rules for Airport Operator; Noise Comparison Used in Important Chester County Property Owner Test Case Reversal. Alexander McSurely. *Aviation Week*, Vol. 48, No. 16, April 19, 1948, pp. 42, 45, 46, 49, illus.

Maintenance (25)

Problems of Maintenance Versus Design. Thos. G. Cribb. *Canadian Aviation*, Vol. 21, No. 4, April, 1948, pp. 56, 58, illus.

The inaccessibility for servicing, maintenance, and replacement of aircraft parts and components has been due to the difficulty of the designer in visualizing accessibility from his drawings. Liaison with the inspection and maintenance departments during the prototype stage could remedy this defect.

The Salvage of Landplanes. R. A. Fry. *The Technical Instructor*, Vol. 3, No. 3, March, 1948, pp. 11–14, illus. An outline of salvage procedure including precautions to be taken prior to lifting or moving a crashed airplane and the proper use of slings, cranes, lifting bags, and trollies.

Douglas Service, Vol. 6, No. 4, April, 1948. 20 pp., diagrs.

Contents: Landing Gear Warning Lights—Description and Operation, DC-6. Identification Marking of Bolts. Geneva-Loc Actuators, DC-6. Torque Chart—Torque Values for All DC-3 and C-47 Series Airplanes. DC-6 Cabin Air Temperature Conditioning System—Flow Schematic of Ducting. Keep it Clean—Importance of Filtering Supercharger Oil, DC-6. Cabin Supercharger Test Panel, DC-6. Take-Off Warning Switches—Operation and Trouble Shooting of System, DC-6. Electrical Wire Identification—Method of Easily Identifying Wires, DC-6. Static System Tester—Adapter for Checking Out System, DC-4, DC-6. Service Hints—Cowl Flaps Spacer, Conduit Attach Fittings, DC-4. Cabin Pressure Amplifier Tester, DC-6. Prop De-Icer Protective Relay—Types and Adjustment of Relays, DC-6.

Management & Finance (45)

How the Air Force Buys. I. J. R. Martin. *Plane Facts*, Vol. 5, No. 3, March, 1948, pp. 6, 7, 32, illus. Overall procurement policy.

Materials (8)

METALS & ALLOYS

A Theory of Static and Dynamic Hardness. D. Tabor. *Engineering*, Vol. 165, No. 4287, March 26, 1948, pp. 289–292, figs.

An analysis of the main characteristics of hardness measurements shows that they are essentially a measure of the elastic limit of the material being examined. With spherical indenters the amount of work hardening and hence the elastic limit increases with the size of the indentation, and the measurements provide information as to the elastic limit of the material and as to the way in which the elastic limit increases with the amount of deformation. The analysis shows to the first approximation that the work-hardening index x is related to the Meyer index n by the relation $x = n - 2$. In this way a series of hardness measurements with a spherical indenter may be used to determine the degree of work hardening of a given metal.

Engineering Materials. R. W. Bailey. *Institution of Mechanical Engineers, Proceedings*, Vol. 157, *War Emergency Issue No. 31*, pp. 274–277, 2 pp. of illus.

A general discussion of the behavior of materials. The values obtained from tensile-strength, ductility, and notched-bar tests as well as the plastic strains in a material can serve as an index of service behavior. Most failures observed in service arise from the introduction of unexpected stress or excessive stress concentrations, the presence of defects that cause stress concentrations, operating conditions that result in intergranular weakness and cracking, and corrosion of the material.

Metallurgical Examination of Airframe Sections From "Zeke," "Val," "Lilly," and "Dinah" Japanese Planes. L. H. Grenell, J. R. Cady, J. G. Dunleavy, and J. W. Gillett. *Gt. Brit., British Intelligence Objectives Sub-Committee, Report No. B.I.O.S./J.A.P./P.R./1480*, August 10, 1944. 14 pp., illus., diagrs., tables. British Information Services, New York. $0.70. The chemical composition and physical properties and the cladding and the surface treatment applied to the alloys used.

An Experimental and Theoretical Investigation of Diffusion in a Two-Phase Alloy. Vera Daniel. *Royal Society of London, Proceedings, Series A*, Vol. 192, No. 1031, March 18, 1948, pp. 575–592, figs. 6 references.

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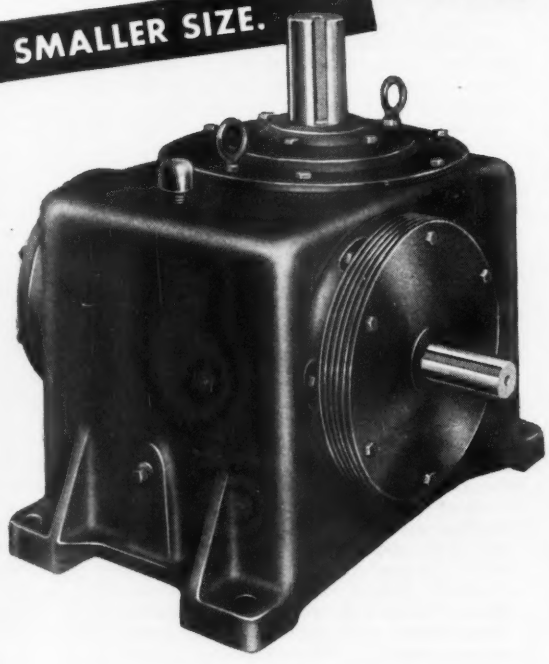

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NONMETALLIC MATERIALS

Ceramic Materials for Some Special Applications. B. C. Weber. *U.S., Air Force, Air Technical Intelligence, Technical Data Digest*, Vol. 13, No. 10, May 15, 1948, pp. 7–11, figs., table.

The porcelain, pyrometric porcelain, sintercorund, libomasse, heizkörpermassen, and silicon carbide masses produced by the Siemens Neuhaus Porcelain Factory for application in the electrotechnical field, in general, differed from American porcelains in a higher refractoriness caused by their lower feldspar content. The manufacturing techniques differed not only in the Seger-Cone number but also in the materials treatment, casting, firing techniques, and production control methods. Limited production of silicon masses were undertaken for use as generator nozzles in producer-gas-powered automobiles. The temperature at the head of the nozzle in operation was 1,200°–1,400°C. A similar ceramic material was used in the experimental production of turbine blades. A table of strength characteristics of some of the materials, a graph of the firing conditions in the 60m.³ Steatite Round Kiln, and an explanation of European industrial terminology are included.

Plastic Bonding. Charles J. Moss. *Aircraft Production*, Vol. 10, No. 113, March, 1948, pp. 87–89, illus. 12 references.

Description of the Redux method of bonding metal to metal, wood, and phenol-formaldehyde plastics. Comparison of the results of small-scale tests and tests on entire structures show its superiority over both riveted and spot-welded joints. In aircraft applications it has produced wing and fuselage panels with a 25 per cent greater shear strength. The process is less expensive than riveting or spot welding and skin surfaces are not marred by rivet heads. It also makes it possible to reinforce wooden aircraft skins with metal to distribute concentrated loads.

The Identification of Aircraft Timbers. G. Fitzgerald-Lee. *Aircraft Engineering*, Vol. 20, No. 229, March, 1948, pp. 70–73, illus. A review of the basic tissue differentiation and structure of wood. Descriptions of 17 woods used in aircraft construction give the characteristics by which they can be identified.

Summary Report of Technical Industrial Forest Products Developments in Germany. Carlisle P. Winslow. *U.S., Field Information Agency, Technical, Final Report No. 571*, December 17, 1945. 72 pp. British Information Services, New York. $2.05.

A summary of the more significant findings and the conclusions of the investigators on 303 targets in the American and British zones. The subjects covered include: improved and modified wood; the manufacture of plywood, glue-wood products and related products; wood preservation; wood structures, fasteners, laminated members, and wood conversion equipment; pulp and paper; wood chemicals; and forestry. The titles of the individual reports on which this summary is based are listed and keyed to a list of the targets.

Meteorology (30)

Atmospheric Waves in the Northwestern United States. Seymour L. Hess and Harold Wagner. *Journal of Meteorology*, Vol. 5, No. 1, February, 1948, pp. 1–19, figs. 19 references.

A partial report or research into the meteorology of the continental area west of the Rocky Mountains between 40° and 50° N. latitude. The project was sponsored in part by the U.S. Army Air Weather Service at the University of Chicago.

On the Distribution of Temperature and Wind in the Upper Westerlies. E. Palmen. *Journal of Meteorology*, Vol. 5, No. 1, February, 1948, pp. 20–27, figs. 11 references.

Navigation (29)

Minimal Flight Paths. Irving I. Gringorten. *Navigation*, Vol. 1, No. 9, March, 1948, pp. 194–202, figs. 9 references.

A technique of plotting a minimal or shortest-time flight path which requires from 7 to 27 min. to complete. A single drift-correction angle is found by a formula and from it a single-heading path is plotted. Corrections for tail-wind effects applied to this plot yield the minimal flight path. The method should be satisfactory for nonstop flights over 500 miles in range.

Navigation and Precision Aerial Photography. Roy C. Gunter. *Navigation*, Vol. 1, No. 9, March, 1948, pp. 202–207, illus. 3 references.

By using both optic and electronic techniques it is possible to take a photograph on which a control point can be located with an accuracy of 50 ft. in 275 miles. The Wright Field Photographic Laboratory and the 7th Geodetic Control Squadron of the 311th Reconnaissance Wing use a "Shoran"-type radar distance-measuring system to orient the airplane. A camera mount was designed which was kept in vertical orientation by servo motors. The control of the motors was accomplished by an electronic circuit that responded to variations in the intensity of light beams reflected from a pair of mirrors mounted on a vertical gyroscope.

Flying the New VOR Omnidirectional Ranges. Carl Fox. *Southern Flight*, Vol. 29, No. 4, April, 1948, pp. 14, 15, 29, illus.

The operation, employment, and facilities provided by the VHF-omnidirectional navigational aids being installed by the C.A.A. The way in which they are used is illustrated by the detailed narrative of a typical flight from New Jersey to Chicago.

Physical Basis of Bird Navigation. Remarks. Joseph Slepian, Russel H. Varian, Leverett Davis. *Journal of Applied Physics*, Vol. 19, No. 3, March, 1948, pp. 306–308. (Cf. AER 3/48:66.)

Operations

COMMERCIAL (41)

Delays in the Flow of Air Traffic. E. G. Bowen and T. Pearcey. *Royal Aeronautical Society, Journal*, Vol. 52, No. 448, April, 1948, pp. 251–258, diagrs. 5 references.

A mathematical study of air-traffic control. The random characteristic of arrivals of aircraft at an airport and the need for spacing them in time for safety make some type of holding procedure inevitable. The analysis shows that as the utilization of airport facilities approaches a maximum their saturation point is approached more and more rapidly. The maximum capacity of an airport is not its optimum working capacity. Excessive delays can be avoided only by a large reserve capacity.

Proposed Domestic Freight Routes. *Aviation Week*, Vol. 48, No. 19, March 29, 1948, p. 40, map. Certificated all-cargo routes recommended by C.A.B. examiners.

Get Better Landings With All-Weather Roll-Ons. Ralph S. Johnson. *Air Transport*, Vol. 6, No. 3, March, 1948, pp. 34–37, diagrs. Outline of the technique and a discussion of the advantages of roll-on landings.

On Airborne Refuelling. Roy Pearl. *Flight*, Vol. 53, No. 2045, March 4, 1948, pp. 250, 251, illus.

Description of a trial refueling operation by the British Overseas Airways Corporation on a scheduled north Atlantic crossing and a discussion of the method of selecting refueling points and the determination of optimum fuel loads. Close proximity of the aircraft makes the operation highly sensitive to weather conditions. Present design of tankers does not provide sufficient ceiling to ensure ability to climb above bad weather. Both present technique and the designs of the tanker and the receiving craft do not permit the pilot of the receiver to remain in complete control during the entire operation.

The Operation of Refuelling in Flight. C. H. Latimer-Needham. *Air World*, Vol. 1, No. 2, February, 1948, pp. 31–37, illus.

Description of the in-flight refueling technique used in trial operations by British South American Airways on the London-Bermuda run. A series of sketches illustrate the sequence of operations from the lowering of the hauling line by the receiver to the final departure of the tanker.

Future Developments in Air Transport. F. N. Hillier. *Institute of Transport, Journal*, Vol. 22, No. 17, February-March, 1948, pp. 625, 626.

Twelve Years of Progress; Development of Irish Airlines. I—From DH84 to Constellation. II—Constellations Provide Increased Capacity. *Modern Transport*, Vol. 54, Nos. 1511, 1513, March 13, 27, 1948, pp. 9; 9; illus.

Map of Routes of U.S.S.R. Internal Air Lines. *Aeronautics*, Vol. 18, No. 5, April, 1948, p. 66.

Index to Items which Have Appeared in the First 991 Numbers of the Bulletin of Information (Years 1922 to 1946). *International Commission for Air Navigation, Bulletin of Information No. 992*, December 31, 1946. 57 pp.

Contents: Applications of the Air Convention of 13th October 1919. International Conventions. National Laws. National Regulations: Permanent General Regulations, Temporary General Regulations, Permanent Local Rules, Temporary Local Rules. National Aircraft Registers. Requirements for Issue of Certificates and Licenses. Statistics.

MILITARY (24)

Der Schlachtflieger in der Panzerschlacht (The Combat Pilot in Tank Warfare). *Flugwehr und -Technik*, Vol. 10, No. 1, January, 1948, pp. 6, 7.

Passiver Truppenluftschutz (Passive Protection of Troops from Air Attack). *Flugwehr und -Technik*, Vol. 10, No. 1, January, 1948, pp. 7–9.

P-80 Gunnery Surprisingly Accurate. *Plane Facts*, Vol. 4, No. 6, December, 1947, pp. 20, 21, illus.

Personal Flying (42)

Air Power From Private Flying. Luis De Florez. *Southern Flight*, Vol. 29, No. 4, April, 1948, pp. 12, 18.

The widespread use of private aircraft would serve as a valuable air-power asset by providing military pilots who have had pre-military training. Before private flying can become popular, landing and airport facilities must be established which will permit the private flyer to have a private destination.

Better Travel by Private Plane. I. Neil B. Berboth. *Southern Flight*, Vol. 29, No. 4, April, 1948, pp. 10, 11, tables.

An evaluation of the four-place airplane as a transportation unit. Itemized and total operating costs are tabulated for eight current models and the average cost and duration of a 100-mile trip is compared with a similar trip by automobile, bus, railroad coach, railroad first class, and air line.

The Secret of the Level Turn. Winfield S. Parks. *Air Facts*, Vol. 10, No. 12, December 1, 1947, pp. 29–34, illus.

Photography (26)

A Microflash Unit for Ballistic Photography. W. W. McCormick, L. Madansky, and A. F. Fairbanks. *Journal of Applied Physics*, Vol. 19, No. 3, March, 1948, pp. 221–225, illus.

The design, construction, and electric circuits of a flash lamp for the photographing of missiles in flight by reflected light. The decay time of the flash is reduced and multiple flashing is eliminated by confining the discharge to a hydrogen and krypton atmosphere contained in a 1-mm. space between two glass walls. The lamp is fired by a capacitance of 0.5 mf. charged to somewhat more than 10,000 volts and attains a peak intensity between 4×10^6 and 6×10^6 equivalent candlepower with respect to a caesium detector for a period of from 1 to 2 microsec.

Power Plants

The Art of the Aviation Engine. F. R. Banks. (The First Louis Blériot Lecture.) *Presented before the Association Française des Ingénieurs et Techniciens de l'Aéronautique, Paris*, May 12, 1948. 27 pp., diagrs.

The development of an aircraft engine requires the joint activity of industry, government, and the engineer. An engine should be designed for a specific application and normally it will grow through a series of marks or modifications to form a family of engines. For the sake of efficiency and economy, the rapid development of the original engine and the succeeding marks requires that the policy of the government toward the producing industry be well conceived and executed intelligently with an understanding of the unique problems of the industry. The contracting firm, in order to avoid waste of time and man power, should have a past history of rapid and satisfactory engine production work. It should be sufficiently large and well organized to provide adequate staff and personnel for the many departments that are required and should be geared for intense development and testing of the engine and components.

American Aircraft Engines. *Western Flying*, Vol. 28, No. 4, April, 1948, pp. 64, 66–68, 70–72, 74–80, illus.

Visualized Engine Data; Assembled Information on Piston and Turbine Engines. *Aeronautics*, Vol. 18, No. 5, April, 1948, pp. 42–45, figs.

Two charts showing the trends in the development of British Aircraft engines. Thrust and thrust-horsepower are plotted against velocity for typical turbojets and propjets. Principle features are tabulated for one radial and one in-line internal combustion engine typical of each 10-year period from 1914 through 1946.

JET & TURBINE (5)

The Application of Gas Turbines to Aircraft. Arthur N. Tifford. *Aeronautical Engineering Review*, Vol. 6, No. 7, July, 1948, pp. 33–41, diagrs. 3 references.

A study of some aspects of the relative performance of aircraft powered solely by current turbojets, turboprops, or turbo-supercharged reciprocating engines. The decrease with altitude and flight speed of the specific fuel consumption of these aircraft may be approximated by the expression, S.F.C. $= K/V^n$ in which K is a function of the component efficiency levels, the type of engine, and the altitude, and $n = 0.85$ for the average current turbojet engine and 0.1 for the average current turboprop design. This inverse power law is used to obtain a quantitative analysis of the range benefits of turbo power plants which shows that there is a maximum range that can be achieved with each weight class. For the 60,000-lb. aircraft this is 3,300 miles. The use of an adjustable exhaust area will not increase this maximum range but will make possible the realization of "high-altitude" ranges at low altitudes. For a maximum cruising altitude of 35,000 ft., aircraft with top speeds below 335 m.p.h. achieve their maximum range when powered by reciprocating engines. Aircraft with top speeds above 610 m.p.h. have maximum range when powered by turbojets. Between these two speed limits the turboprop engine in general gives the maximum range. Aircraft designed for an extreme range greater than 9,500 miles have highest top speeds when powered by reciprocating engines. For ranges less than 2,500 miles, highest top speed will be provided by a turbojet engine, and for ranges between 2,500 and 9,500 miles the turboprop engine in general gives the highest top speed.

Parameters Determining Performance of Supersonic Pilotless Airplanes Powered by Ram-Compression Power Plants. Paul R. Hill. *U.S., N.A.C.A., Advance Confidential Report No. L6D17 (Wartime Report No. L-755)*, June, 1946. 91 pp., figs. 7 references.

Calculations for supersonic continuous-flow ram-compression power plants demonstrate favorable thrust and economy characteristics. With a cylindrical entrance pipe in which the normal-shock loss occurs, a fuel-air ratio of 0.033, a flight Mach Number of 2.0, and standard sea-level air density, computed thrust is 3,000 pounds per sq.ft. of cross-section area and the specific fuel consumption is 0.65 lb. per thrust-hp.hr. Computations show that it is possible to operate a fixed design over a range of supersonic speeds and that the thrust can be regulated by changing the amount of fuel injected. Calculations are made on a simple pilotless airplane consisting of a cylindrical body with a conical nose, and a wing and a tail of circular arc sections and 5 per cent thickness ratio. At flight Mach Numbers from 1.5 to 4.0 performance was favorable and at Mach 4 a range of 1,200 miles was calculated.

The Constant-Volume Gas Turbine (Project No. EP-185). Peter G. Kappus. *U.S., Air Force, Technical Report No. F-TR-2195-ND (GS-USAF-Wright Patterson Air Force Base No. 74)*, March, 1948. 12 pp., diagrs.

A comparison of the fundamental theromodynamic characteristics of the constant-volume combustion gas turbine and the constant-pressure gas turbine. Calculations, based on 100 per cent efficiency, in which the effects of temperature and air-fuel ratio on the ratio of specific heats have been ignored, show the fuel-consumption characteristics of the constant-volume system to be superior. Increased output efficiency can be obtained without a corresponding increase in pressure ratios, and hence multiplication of stages in the compressor and the turbine can also be achieved.

Gas Turbine Accessory Systems. O. N. Lawrence. *Royal Aeronautical Society, Journal*, Vol. 52, No. 447, March, 1948, pp. 151–174, Discussion, pp. 174–185, illus., diagrs. 2 references.

An outline of the basic requirements that must be fulfilled by the fuel-supply, starting, and ignition systems of gas-turbine engines. The fuel system must be capable of delivering to the burners a predetermined quantity of fuel in a condition suitable for ignition. This quantity or rate of flow must be sensitive to changes in operating conditions, barometric pressure, temperature, r.p.m. of the engine, and acceleration. In discussing the principles and the devices that have been used to accomplish this control, each method is evaluated with respect to the three types of engine under discussion: the jet engine, the shaft or "work-turbine" engine, and the "compressor-turbine" engine. Starting requires a special control of fuel delivery which may be accom-

plished by a starting pump, an accumulator system, flow boosters, or two-stage starting. In addition to the conventional spark-plug type of ignition, heated electrodes and recessed plugs with a individual fuel supply to provide a torch igniter have been developed to ensure reliability of ignition.

Combustion in Moving Air. Frank R. Caldwell, Fillmer W. Ruegg and Lief O. Olsen. *Preprint, S.A.E. National Aeronautic and Air Transport Meeting*, New York, April 13–15, 1948. 23 pp., illus., figs. 10 references.

A review of the basic concepts employed in a theoretical analysis of combustion in a moving air flow. The principal problems currently under investigation are flame stabilization and combustion at high and at low temperature ratios. The combustion systems are divided into those using homogeneous and those using hetereogeneous fuel-air mixtures. The heterogeneous systems are further subdivided according to whether fuel and air are premixed, or are mixed during combustion, or whether the fuel is injected as a vapor or a liquid. The results of experiments conducted at the National Bureau of Standards, M.I.T., and elsewhere are summarized.

Ideal Temperature Rise From Constant Pressure Combustion of Hydrocarbon Fuels. Newman A. Hall and Richard C. Mulready. *Preprint, S.A.E. National Aeronautic and Air Transport Meeting*, New York, April 13–15, 1948. 14 pp., figs. 4 references.

An analysis of the thermodynamics of constant-pressure combustion. The data is organized in a series of charts based on a reference fuel having a hydrogen-carbon mass equal to that of $C_{12}H_{26}$ and a constant-pressure lower heating value of 19,000 B.t.u. per lb. The basic chart provides a direct reading of temperature rise in terms of fuel-air ratio. Subsequent charts provide corrections for the heat absorbed during combustion, deviation from the reference heating value, variations in the fuel hydrogen-carbon mass ratio, and for the effect of moisture on temperature rise. The charts for afterburning combustion are based on the assumption of an ideal process in which the net products of the primary combustion are removed so that the secondary combustion occurs in pure air. The net products are then added and mixed following the secondary combustion. From it the net secondary fuel-air ratio can be determined in terms of the gross primary and secondary fuel-air ratios, these latter being the ratios of the corresponding fuel flows and the air supplied to the primary combustion plus any fresh air supplied to the secondary combustion. Each of the correction factors is strictly valid only when applied independently to the basic chart. In many cases, however, a cumulative application will give sufficiently accurate results for engineering practice.

From Supercharger To Turbojet. Scholer Bangs. *Aviation Week*, Vol. 48, No. 15, April 12, 1948, pp. 23, 24, illus., diagr.

The West Engineering Co., Inc., has modified a war-surplus Type-B airplane supercharger by the addition of a single reverse-flow combustion chamber, a special injector nozzle, and intake and exhaust ducts. By improving the design of the turbine buckets a thrust of 280 lbs. at 26,000 r.p.m. has been obtained. By further improving the design of the air-intake inducer it is expected to obtain 400-lbs. thrust and a specific fuel consumption of 1.3 lbs. per hr.

Controls for Gas Turbine Propellers. R. C. Treseder. *Preprint, S.A.E. National Aeronautic and Air Transport Meeting*, New York, April 13–15, 1948. 15 pp., diagrs. 9 references.

The turboprop power plant can be controlled in a manner similar to the conventional control of reciprocating engines. A system can be provided which will enable the pilot to control the pitch of the propeller and, in turn, will govern the r.p.m. of the turbine. The temperature of the turbine in this case is controlled by a temperature-sensitive element that meters the fuel supply correspondingly. An alternative system, because of the limited speed range of the turbojet power plant, could control the speed of the turbine by a torque-sensitive governor in turn controlling the fuel supply. In this case the temperature of the turbine would be controlled by an automatic variation in the pitch of the propeller. Any constant-speed propeller control for gas turbines must contain sufficient artificial damping to compensate for the lack of natural damping inherent in the turboprop combination. During taxiing and reverse thrust the pilot would have to control the blade angle directly while the fuel governor maintained a preselected speed of rotation. Regardless of the type of propeller control used, it would have to be so interlocked with fuel control that large changes in fuel rate and speed governor setting would be made simultaneously.

Armstrong Siddeley "Mamba" Gas Turbine Propeller Engine. *The Engineer*, Vol. 185, No. 4809, March 26, 1948, pp. 301–303, diagrs.

A detailed description of the construction and design of the power plant; including propeller reduction gear, compressor and turbine assembly, and the combustion, fuel, lubricating, and starting systems.

Engines Compounded for More Power. Dimitrius Gerdan and J. M. Wetzler. *SAE Journal*, Vol. 56, No. 1, January, 1948, pp. 59, 60, fig. (Summary of a paper: Allison V-1710 Exhaust Turbine Compounded Reciprocating Aircraft Engine.)

Engines Compounded for More Power. Erold F. Pierce and Harvey W. Welsch. *SAE Journal*, Vol. 56, No. 1, January, 1948, pp. 58, 59, 61, 62, diagrs. (Summary of a paper.)

Turboprop Problems Solved in Minutes. G. A. Philbrick, W. T. Stark, and W. C. Shaffer. *SAE Journal*, Vol. 56, No. 1, January, 1948, p. 63, illus. (Extended summary of a paper.)

The Effect of Inlet Temperature and Pressure on the Efficiency of a Single-Stage Impulse Turbine Having a 13.2-Inch Pitch-Line Diameter Wheel. Ernest R. Chanes and L. Robert Carman. *U.S., N.A.C.A., Advance Restricted Report No. E5H10 (Wartime Report No. E-232)*, September, 1945. 23 pp., illus., tables 3 references.

The Effect of Inlet Pressure and Temperature on the Efficiency of a Single-Stage Impulse Turbine Having an 11.0-Inch Pitch-Line Diameter Wheel. David S. Gabriel, L. Robert Carman, and Elmer E. Trautwein. *U.S., N.A.C.A., Advance Confidential Report No. E5E19 (Wartime Report No. E-218)*, June, 1945. 30 pp., figs. 4 references.

Jet Engine Progress Keyed to Fabrication, Metallurgy. E. M. Phillips. *SAE Journal*, Vol. 56, No. 1, January, 1948, pp. 66, 67, figs. (Extended summary of a paper: The Metallurgical Aspects of Turbine Wheels and Nozzles.)

10 Ways to Attach Blades. A. T. Colwell and R. E. Cummings. *SAE Journal*, Vol. 56, No. 2, February, 1948, pp. 32–35, diagrs. (Extended summary of a paper: Turbine Engine Blading; Manufacturing Technique and Fastening Methods.) Description of ten methods of attaching blades to wheels and casings of turbine power plants.

French Jet Program Gathers Momentum. *Aviation Week*, Vol. 48, No. 14, April 5, 1948, p. 22.

Jet propulsion aircraft engines either are being produced in France under foreign license or are in the developmental stage. German technicians are being used in the development program. In the case of the SNECMA ATAR the German BMW-003 served as the basic design.

RECIPROCATING (6)

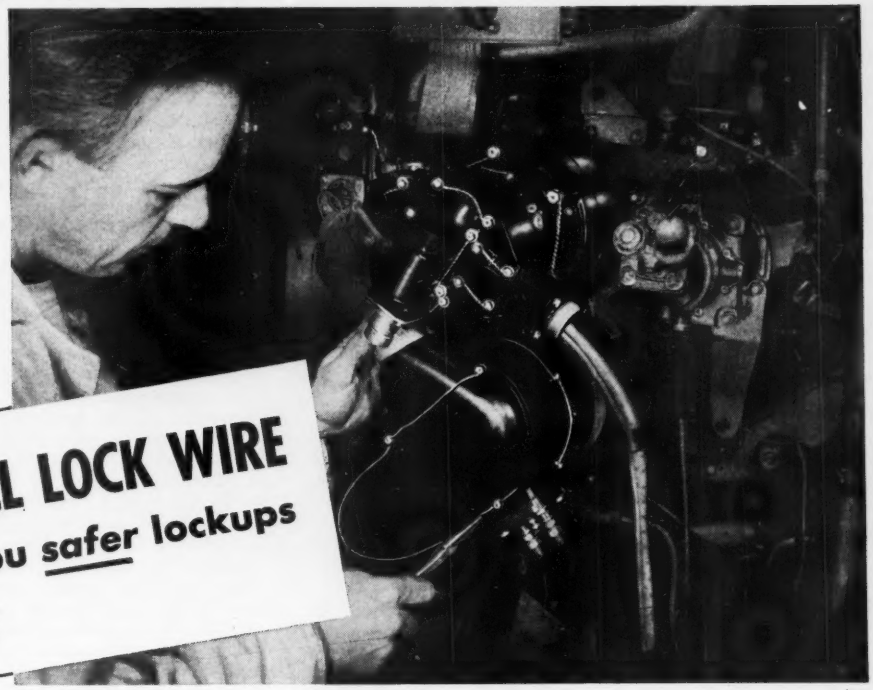
Air Transport Maintenance and Engineering Aspects of Powerplant Controls. Harry W. Nevin. *Preprint, S.A.E. National Aeronautic and Air Transport Meeting*, New York, April 13–15, 1948. 6 pp.

A summary of the characteristics of cable and pulley transmission for power-plant controls. In spite of the difficulty of maintaining a constant tension under varying operating temperatures, they are preferred to other types by transport operators because of their linearity, direct action, and low weight factor. Torque tubes are too heavy. Flexible push-pull and torsional controls encased in a guide tube develop too much internal friction and are too difficult to inspect and lubricate. Electric or electronic controls make the power plant and the electrical system interdependent. All control transmission systems are sensitive to vibration, and this common type of failure can be eliminated only by more extensive testing of the components of the system before adoption in an aircraft specification.

The Variation of Power With Height of the Merlin XX Engine as Determined by Flight Tests on a Hurricane II. G. S. Hislop and R. H. Weir. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2212*, January, 1942. 23 pp., illus., figs. British Information Services, New York. $1.45.

A method of determining the variation in power of an aircraft engine with altitude. Using a fixed-pitch propeller, the variation of full throttle power under still air conditions of the Merlin XX in high supercharger gear expressed as a function of density was found to be Power $\propto 1.08\sigma - 0.08$.

The Variation of Power With Height of a Merlin 46 Engine as Determined by Flight Tests on a Spitfire Vc. G. S. Hislop. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda*



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No. 2213, September, 1943. 14 pp., illus., figs. 5 references. British Information Services, New York. $1.00.

An electric constant-speed propeller that can be locked in pitch was shown to be satisfactory for determining the power law of an engine in the absence of a torquemeter. The variation of full throttle power with altitude of the Merlin 46 engine under still air conditions when expressed as a function of density was found to be virtually the same as that obtained from previous flight tests Merlin engines. The observed supercharger compression-ratio temperature coefficient of 0.00248 compares with the accepted value of 0.002 for Merlin engines.

Spark Plug Fouling and Mixture Distribution. P. G. Pigneguy and J. G. Dawson. *Shell Aviation News*, No. 117, March, 1948, pp. 14–22, illus., figs.

Prolonged low-power operation of aircraft was found to cause spark-plug fouling. Single cylinder tests determined the deposits to be the combustion products of tetraethyl lead and of ethylene bromide. Short periods of high power during sustained low-power operation were found to prevent the formation or to remove the deposits formed. In full-scale engine tests various pistons were unequally susceptible to fouling. Two causes were found for this. The intake manifold and supercharger imparted swirl to the fuel-air mixture which prevented the uniform distribution of the unvaporized particles of fuel. These droplets of fuel contained an excess of tetraethyl lead and were deficient in ethylene bromide because of their different boiling points. It was found that the maldistribution of the fuel could be overcome by mechanical atomization or deflection by swirl baffles, by maintaining the induction mixture temperature above the critical or dew point temperature of the fuel, or by the use of direct or individual cylinder fuel injection. The fuel itself could be modified to reduce the formation of combustion-waste deposits by using as a lead scavenger, instead of ethylene bromide, a halide having a boiling point close to that of tetraethyl lead; by reducing the lead content of the fuel; or by increasing the volatility of the fuel and excluding the heavy ends.

Analysis Clarifies Economics of Airplane Engine Weight. John W. Thorp. *SAE Journal*, Vol. 56, No. 1, January, 1948, pp. 40–42, 46, figs. 3 references. (Extended summary of a paper: Future Power for the Personal Airplane.)

Master Control Fuel Injection System for Aircraft Engines. H. M. Hobson, Ltd. *The Technical Instructor*, Vol. 3, No. 3, March, 1948, pp. 3–10, diagrs.

Detailed design description of a bulk injection system. The injection carburetor developed by the Hobson Company meters the fuel delivered, which is injected on the downstream side of the throttles, by a variable metering orifice. The area of the orifice is proportional to the absolute induction and exhaust back pressures, and the pressure difference across the orifice is maintained proportional to the square of the engine speed. This system eliminates the performance difficulties met with in conventional carburetors at high altitudes and under icing and negative *g* conditions.

Fuel Injection Without Injection Pump. A. M. Madle. *U.S., Field Information Agency, Technical, Final Report No. 621*, December 17, 1945. 12 pp., diagrs. British Information Services, New York. $0.55.

Hirth Motoren A.G. developed a method of pumpless fuel injection that is a refinement of the L'Orange patent. During the intake stroke of the engine a small quantity of a special fuel that ignites at a compression ratio of 8:1 is drawn into and through a venturi into the main cylinder. During the compression stroke the intake valve for the special fuel closes, and, before the end of the compression stroke, the fuel in the ignition chamber ignites. The products of combustion pass through the venturi to the main cylinder, at the same time reopening the special-fuel intake valve and carrying with them additional special fuel. This burning mixture of the products from the ignition chamber and the second charge of special fuel bring about the ignition of the normal air-fuel mixture in the cylinder.

Effect of Water Injection on Knock-Limited Performance of a V-Type 12-Cylinder Liquid-Cooled Engine. Myron L. Harries, R. Lee Nelson, and Howard E. Berguson. *U.S., N.A.C.A., Memorandum Report* (*Wartime Report No. E-244*), September, 1944. 44 pp., illus., figs.

Supercharged Loop Scavenging. A. M. Madle. *U.S., Field Information Agency, Technical, Final Report No. 620*, March 29, 1946. 11 pp., diagrs. British Information Services, New York. $0.55.

Data on development of a valveless two-cylinder engine. Intake and exhaust ports in the cylinder walls permit the introduction of a blast of supercharged air to effect scavenging. The cylinder-wall port is so designed that the airstream is directed in a loop that terminates at the exhaust ports. Fuel is injected into the air entrapped during the return stroke of the piston.

High Pressure Chemical Liquid Pump; Force Feed Lubricators; Positive Rotary Supercharger (Manufactured by Robert Bosch G.m.b.H., Stuttgart). R. C. Mathewson. *U.S., Field Information Agency, Technical, Final Report No. 594*, March 27, 1946. 10 pp., diagrs. British Information Services, New York. $0.35.

Knock-Limited Power Outputs From a CFR Engine Using Internal Coolants. I—Monomethylamine and Dimethylamine. Donald R. Bellman, W. E. Moeckel, and John C. Evvard. *U.S., N.A.C.A., Advance Restricted Report No. E4L21* (*Wartime Report No. E-228*), December, 1944. 22 pp., figs. 8 references.

Effect of Local Boiling and Air Entrainment on Temperatures of Liquid-Cooled Cylinders. A. P. Colburn, Carl Gazley, E. M. Schoenborn, and C. S. Sutton. *U.S., N.A.C.A., Technical Note* No. 1498, March, 1948. 75 pp., illus. 17 references.

A special bench-rig apparatus was used to measure the coefficients of heat transfer of the coolant film. They are correlated as dimensionless parameters as a function of Reynolds Number. When the wall-coolant interface temperature is below the boiling point of the coolant under existing pressures, data are in close agreement with the conventional equations for heat transfer in round pipes and annular spaces. When the interface temperature is above the boiling point of the coolant, local-boiling effects were observed, and the heat-transfer rates were found to depend primarily on the temperature excess of the wall over the liquid boiling point and upon the velocity of the coolant past the heating surface. At low liquid velocities, the heat-transfer coefficient increased with increasing values of this temperature difference. The maximum increase noted was 300 per cent. Entrained air also increased the heat-transfer coefficients a maximum of 100 per cent.

An Experimental Investigation of Rectangular Exhaust-Gas Ejectors Applicable for Engine Cooling. Eugene J. Manganiello and Donald Bogatsky. *U.S., N.A.C.A., Advance Restricted Report No. E4E31* (*Wartime Report No. E-224*), May, 1944. 49 pp., illus., diagrs. 11 references.

High-Altitude Cooling. *U.S., N.A.C.A.*

I—Résumé of the Cooling Problem. Abe Silverstein. *Advance Restricted Report No. L4I11* (*Wartime Report No. L-771*), September, 1944. 35 pp., figs., tables. 6 references.

II—Air-Cooled Engines. David T. Williams. *Advance Restricted Report No. L4I11a* (*Wartime Report No. L-772*), September, 1944. 36 pp., figs. 5 references.

IV—Intercoolers. K. F. Rubert. *Advance Restricted Report No. L4I11c* (*Wartime Report No. L-774*), September, 1944. 15 pp., figs. 9 references.

V—Cowling and Ducting. S. Katzoff. *Advance Restricted Report No. L4I11d* (*Wartime Report No. L-775*), September, 1944. 22 pp., diagrs., figs. 15 references.

VI—Axial-Flow Fans and Cooling Power. William Mutterperl. *Advance Restricted Report No. L4I11e* (*Wartime Report No. L-776*), September, 1944. 70 pp., figs., tables. 12 references.

Simulated-Altitude Investigation of Performance of Tubular Aircraft Oil Coolers. S. V. Manson. *U.S., N.A.C.A., Technical Note No. 1567*, April, 1948. 32 pp., diagrs. 4 references.

Presents experimental values of oil heat dissipation, oil pressure drop, and air pressure drop at simulated altitudes up to 40,000 ft. and shows effect of congealing on oil heat dissipation and oil pressure drop. An analytical basis is afforded for correlating and predicting air pressure drops at altitude. Experimental and predicted air-pressure-drop values are compared. For constant oil inlet temperature, congealing of the oil at each altitude produces an initial decrease of about 5 to 10 per cent of the maximum heat dissipation attained at the altitude and is followed by constancy of oil heat dissipation as air flow increases.

Selection of Oil Coolers to Avoid Congealing. Dennis J. Martin. *U.S., N.A.C.A., Memorandum Report* (*Wartime Report No. L-744*), July, 1944. 41 pp., figs., tables. 6 references.

Metallurgical Examination of Oil Cooler from Japanese Aircraft "Betty." E. M. Smith, B. D. Gonser, and H. W. Gillett. *Gt. Brit., British Intelligence Objectives Sub-Committee, Report No. B.I.O.S./J.A.P./P.R./1492*, August 31, 1944. 7 pp., illus.,

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tables. British Information Services, New York. $0.55. Materials, type of construction, and surface finish.

Metallurgical Examination of a Japanese Aircraft Oil Radiator. L. H. Grenell, J. R. Cady, C. A. Reichelderfer, and H. W. Gillett. *Gt. Brit., British Intelligence Objectives Sub-Committee, Report No. B.I.O.S./J.A.P./P.R./1486*, June 17, 1944. 6 pp., illus. British Information Services, New York. $0.35. The design, material, and construction of an oil radiator removed from a 14-cylinder radial aircraft engine mounted on an "Oscar" Japanese fighter airplane.

Metallurgical Examination of a Japanese Sakae-12 Aircraft Engine Mount. L. H. Grenell, J. R. Cady, C. B. Voldrich, P. J. Rieppel, and H. W. Gillett. *Gt. Brit., British Intelligence Objectives Sub-Committee, Report No. B.I.O.S./J.A.P./P.R./1487*, June 24, 1944. 11 pp., illus., tables. British Information Services, New York. $0.55. The materials and the type and quality of the welding.

Metallurgical Examination of a Japanese Aircraft Exhaust Stack and Collector Ring. C. E. Levoe, H. C. Cross, and H. W. Gillett. *Gt. Brit., British Intelligence Objectives Sub-Committee, Report No. B.I.O.S./J.A.P./P.R./1490*, March 21, 1944. 12 pp., illus. British Information Services, New York. $0.55.

The composition and structure of the materials and the fabrication processes used. The engine parts were stamped from thin rolled low-carbon stainless-steel sheet that had been stabilized by the addition of titanium and were gas welded.

ROCKET (4)

Mass Emissivity of Powder Gases in Solid Fuel Rockets. S. S. Penner. *Journal of Applied Physics*, Vol. 19, No. 3, March, 1948, pp. 278–285, figs. 9 references.

An analysis has been carried out to determine an upper limit for the effective mass emissivity of the radiating gases in a solid fuel rocket motor. The calculations depend upon a comparison between experimentally observed performance data relating to a rocket motor and theoretical results based on a theory for the effect of radiation on the performance of a solid fuel rocket motor. A simplified treatment is developed for correlating the rate of burning of the powder with the temperature rise of a powder grain caused by the absorption of radiant energy.

Rocket Propulsion. K. R. Stehling. *Engineering Journal*, Vol. 31, No. 3, March, 1948, pp. 162–166, diagrs. A brief summary of the theory of rockets, their basic design, and fuel requirements.

Production (36)

Report on the Bristol Brabazon: Rear Body and Tailplane Construction; Main Frame and Spar Manufacture; Assembly of Rear Body and Tailplane. *Aircraft Production*, Vol. 10, No. 114, April, 1948, pp. 116–122, illus., diagrs.

de Havilland Dove. II—Sectional Assembly of the Cabin Portion of the Fuselage: Fuselage Rear Section and Fin. *Aircraft Production*, Vol. 10, No. 112, February, 1948, pp. 44–51, illus., diagrs.

The structure, constructed of stringer frame and stressed skin, is built up from individual panels which are first preassembled into sections and then joined to form the entire structure. The outline of the assembly procedure mentions the drilling techniques and locating methods used. Detail drawings show the structure of the center spar, wing-attachment points, window-frame structure, and the method of retaining the perspex window panels by the combined use of rubber and pressure-plastic sealing compound.

de Havilland Dove. III—Mainplane Construction: Main-Spar Assembly; Mainplane Forward Section: Final Assembly. *Aircraft Production*, Vol. 10, No. 113, March, 1948, pp. 79–86, illus., diagrs.

Structural layout, design details of fittings and attachments, and assembly sequence. The leading edge forms the main component and the element from which the wing is built up. The method of positioning subassemblies in fixtures is given and the sequence of drilling from existing holes in preceding elements. The wing moves along its assembly line until at the intersection of the fuselage line its assembly is complete. The aircraft then proceeds sideways on a trolley along the final assembly line while

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the engine bearers are removed and fitted to the engines in a second facing line. At the end of the line the landing gear is fitted and the aircraft is rolled clear of its trolley.

Interrogation of Gen. Dir. K. Frydag and Prof. Dr. E. Heinkel; Some Aspects of German Aircraft Production During the War. F. A. Borchardt. *Combined Intelligence Objectives Sub-Committee, Evaluation Report No. 323*, August 14, 1945. 9 pp.; diagrs. British Information Services, New York. $0.10.

Junkers Aircraft Targets at Dessau, Aschersleben, Bernburg, Raguhn, Schonebeck, Tarthum, Jessnitz, Halle and Schkeudits. L. R. Logan, M. A. B. Lambert, and others. *Combined Intelligence Objectives Sub-Committee, Evaluation Report No. 149*, June 27, 1945. 11 pp. British Information Services, New York. $0.10.

General description of plants, equipment, and manufacture in nine Junkers aircraft production installations. Includes: research, development, and preproduction factory; detail production and assembly unit; final assembly, flight and acceptance test installation; drafting and stress offices; sheet metal plant; machine shop, press shop, and foundry; machine shop and fuselage manufacture and assembly unit; material and structural testing plant; wing production unit; final assembly and flight test establishment.

Junkers Werke, Dessau (JUMO and JFA Plants). Kurt Teutsch. *Combined Intelligence Objectives Sub-Committee, Evaluation Report No. 69*, June 8, 1945. 4 pp. British Information Services, New York. $0.10. Sketch of supervisory personnel; outline of production plan 1934–1943 for the Ju-52, Ju-86, Ju-87, Ju-88, Ju-252, Ju-352, Ju-290, Ju-390; and the effect of Allied bombing on production.

Inspection of S.N.C.A. Du Nord Factory, Meulan-Les-Mureaux, and Three Airfields. C. E. Thompson. *Combined Intelligence Objectives Sub-Committee, Item No. 25, File No. I-11*, September 1, 1944. 8 pp. British Information Services, New York. $0.35. Layout, equipment, and production methods. Inspection Reports of three airfields included.

Engine Production in Australia. D. O. MacFarlane. *Aircraft Production*, Vol. 10, No. 112, February, 1948, pp. 57–61, illus.

The expansion required of the Australian aircraft engine industry in converting to war production was hindered by a shortage of experienced personnel, an inadequate industrial organization, and insufficient testing equipment. Drawings and specifications made in England and America differed in the use of opposite-hand projections and in the amount of detail specified on the drawings. Processes, tolerances, and materials were called for which were unfamiliar to the existing Australian industry which called for the substitution of available materials, development of new materials, and the modification of engine design.

Avis Leonides: Design Details; Batch Production of Major Components. J. A. Oates. *Aircraft Production*, Vol. 10, No. 114, April, 1948, pp. 132–138, illus., diagrs.

Design and manufacture of the nine-cylinder radial air-cooled aircraft engine. Notes the principal features of the casting, shaping, finishing, drilling, and checking of the propeller shaft, the crankshaft unit, the crankcase, rear cover, air intake, and the engine mounting. The individual components are welded in a special sequence to minimize distortion before the final assembly and testing of the engine.

Plastic-Wing Development. *Aircraft Production*, Vol. 10, No. 114, April, 1948, pp. 113–115, illus., diagrs.

Development of the mold and description of the low-pressure molding process used in the experimental fabrication of a wing of sandwich-type structure. The skin and rear spar are of Durestos laminated, impregnated asbestos felt. The main spar is a strip of Aerolite laminated material. Plywood ribs are pitched at 12-in. centers, and the interior is filled with expanded Dufaylite honeycomb.

Pressure Sealing; Some Practical Considerations in the Sealing of Skin Joints, Doors and Cable Fairleads. A. A. Soderquist. *Aircraft Production*, Vol. 10, No. 114, April, 1948, pp. 139, 140, diagrs. A summary of the sealants, sealing devices, and leakage tolerances used by the Boeing Aircraft Company.

Heavy Cuts on Light Alloys; Possibilities of Carbide Tools Still Unrecognized; A Criticism of Machine Designers and Users. H. Eckersley. *Aircraft Production*, Vol. 10, No. 113, March, 1948, p. 105, illus.

Liquid Honing, Wet Abrasive Blasting for Impeller Finishing. *Aircraft Production*, Vol. 10, No. 114, April, 1948, pp. 130, 131, illus., diagrs.

A method of surface finishing and polishing. An atomized jet of mixed water and abrasive is propelled against the surface by an air jet. The de Havilland Engine Company, Ltd., uses this process to finish compressor impellers for Goblin gas turbines. After preliminary scurfing and hand-finishing three successive honings employ increasingly finer abrasive.

Specialized Machining; An Unusual Problem in Boring and Drilling; Production of Lockheed Servodyne Units for the Brabazon. *Aircraft Production*, Vol. 10, No. 114, April, 1948, pp. 141–144, illus.

The body of the Lockheed Servodyne aileron control unit is machined from a solid block of duraluminum without the extensive use of jigs and fixtures. Seven bores and 67 drilled holes, some of which penetrate at an angle to the outer faces, comprise the jacks, valves, and cylinders of the accumulators and form a maze of passages within the body. A special tool is used to produce the ring-seal grooves.

The Economics of Broaching. II—Chip Control; Work Materials; Broach Assemblies; Fixtures. W. A. Carter. *Aircraft Production*, Vol. 10, No. 112, February, 1948, pp. 62–64, diagrs.

Proper design of teeth to produce the smallest chip coil with a given material will produce the best surface finish. The material determines the design of the broach and its optimum speed of operation. The need for resharpening can be determined from the nature of the chips and the life of the broach as well as from its speed, and the force required to operate it depends on the machinability and uniformity of the material. Economical operation can be obtained by using broach assemblies consisting of numerous teeth fitted into holders and by designing the fixture to provide maximum rigidity, smooth power operation, and stepless variation in speed.

Precision Investment Casting. Edwin Laird Cady. *Product Engineering*, Vol. 19, No. 4, April, 1948, pp. 81–85, diagrs.

The economical use of precision investment casting depends on the thermal conductivity, thermal expansion, hot-plastic range, and mushy range characteristics of the materials in which the product may be cast. The design of the product and the heat treatability and machinability of the material selected determine the complexity of the casting process and its ultimate cost.

Rubber Hydraulics; An Ingenious System of Expanding and Contracting Gauges, Tools and Other Components. *Aircraft Production*, Vol. 10, No. 113, March, 1948, pp. 90–92, illus., diagrs.

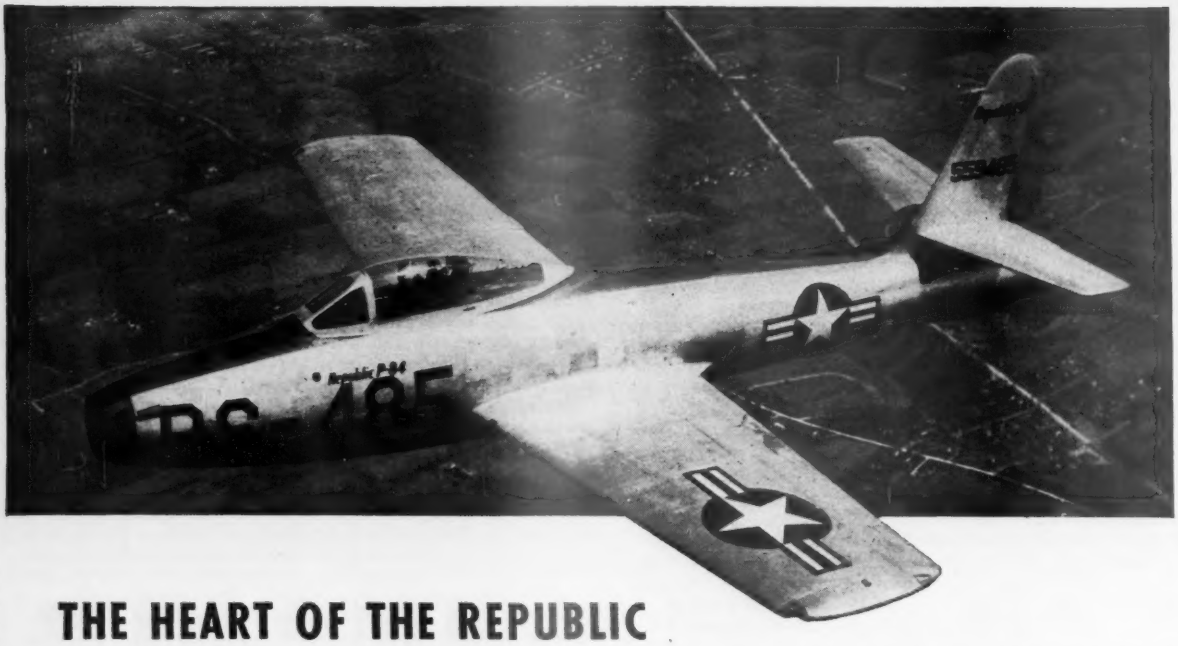
The hydraulic-power transmission properties of rubber are employed to alter the diametrical dimensions of cylindrical bodies. Pressure loading a core or collar of pressure-pliant material transmits a pressure to its metal retaining surfaces and produces either an expansion of the exterior or a contraction of the interior dimension.

Electronic Inspection; Principles and Applications of the Cornelius Comparator. *Aircraft Production*, Vol. 10, No. 112, February, 1948, pp. 52–54, illus.

The Cornelius Comparator, produced by A. C. Wickman, Ltd., Conventry, measures the modulation of a basic frequency which it transmits. Any variation in the composition, structure, state, dimension, or surface finish of the material under test produces a characteristic variation of the modulation. Once an appropriate frequency has been selected and the reading of the instrument for a standard specimen determined, a series of test pieces may be passed through the frequency field transmitted by the probe of the instrument, and visual indication will be obtained of any defect or variation. For dimensional inspection an air gap is left between the probe and the test piece, and the indicator is set to read the modulation produced by the capacitance of the air gap. In certain cases where different composition specifications may yield identical readings, as in the case of steels, the variation of the comparator during the application of a strain to the specimen can be plotted against the strain-gage reading, and a unique pair of curves obtained.

Precision Measurement; Unusual German Apparatus at the College of Aeronautics, Cranfield. I—Three Zeiss Instruments. S. G. Poulsen. *Aircraft Production*, Vol. 10, No. 113, March, 1948, pp. 75–78, illus., diagrs.

In addition to a complete set of original Johansen slip gages, the precision measuring equipment at Cranfield includes a dial micrometer by Carl Mahr and instruments based on optical principles by Ernst Leitz, Wetzlar, and Carl Zeiss. These latter instruments include a gear-tooth checking machine and three micrometer microscopes which are described in detail. The



THE HEART OF THE REPUBLIC
THUNDERJET AILERON CONTROL SYSTEM
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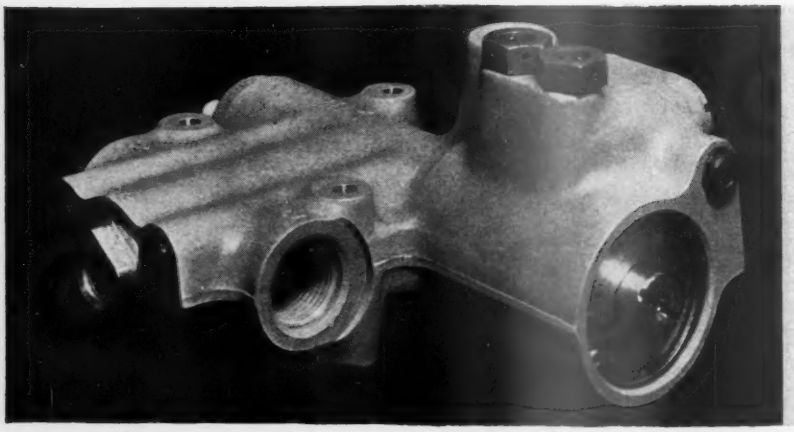

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Diritest is a microhardness tester for the nondestructive testing of small or thin specimens. The diamond indenter and a microscope objective share a common mount and can be swung into the field alternately. A magnification of 350× permits a direct reading of 0.0002 mm. Selective focus allows measurement of depth. The large shop microscope, designed for linear measurements, profiles, and angles, can be inclined to measure such profiles as screw threads which cannot be checked accurately in a plane parallel with that of the worktable or work axis. A projection screen can be substituted for the eyepiece, and two micrometer heads used in conjunction with slip gages and a traversing worktable permit coordinate measurement. Simultaneous viewing of the workpiece and two graticules and a secondary eyepiece and scale in the same ocular are used for direct angular readings to one minute of arc. The universal microscope is of similar design but accommodates larger work and permits coordinate measurement to 0.001 mm.

Precision Measurement. II—Zeiss Gear-Tooth and Cam Checking Machines; Leitz Drill-Spotting Instrument; Carl Mahr Dial Micrometer. S. G. Poulsen. *Aircraft Production*, Vol. 10, No. 114, April, 1948, pp. 126–129, illus., diagrs.

The Zeiss gear-tooth recorder can check profiles to an accuracy of 0.001 mm. The electromechanical recording head produces a record truly linear on both axes at a magnification of 1,000 ×. The cam-profile checking machine has a linear accuracy of 0.001 mm. and an angular accuracy of 1 min. The hollow drilling spindle of the Leitz precision drill-spotting machine incorporates a centering microscope that sights through the spotting-drill chuck. The eyepiece is removable and can be replaced by a flexible power shaft. The Carl Mahr large-capacity dial micrometer is capable of measurement to 0.001 mm. and is massively proportioned in order to maintain its accuracy under normal shop conditions.

Propellers (11)

Type Test of Annesley Two Propeller Model 185 for Use on the L-5 Aircraft. Earl A. Vonderheid. (Whirl Test No. 2124.) *U.S., Army Air Forces, Technical Report No. 5587*, May 16, 1947. 14 pp., illus.

Test of Curtiss Propeller Blades of Design No. 1050-1C4-0 Installed in a Hub of Model No. C644S-B. J. J. Pacey. (Whirl Test No. 2074.) *U.S., Army Air Forces, Technical Report No. 5594*, June 13, 1947. 23 pp., illus.

Electric Motor Whirl Tests of Curtiss C644S-B Propeller With Design 830-2C4-6 Blades. A. E. Shaw. (Whirl Test No. 2009.) *U.S., Army Air Forces, Technical Report No. 5595*, June 13, 1947. 8 pp., illus.

Electric Motor Whirl Test of a 12 Ft. Diameter Dual Rotation Aeroproducts Propeller for the P-47 Airplane. E. K. Grimes. (Whirl Test No. 1785.) *U.S., Army Air Forces*, June 17, 1947. 19 pp., illus. 3 references.

Whirl Test of a Hartzell Propeller With Plastic Blades. C. R. Gaskell. (Whirl Test No. 2039.) *U.S., Army Air Forces, Technical Report No. 5597*, June 17, 1947. 10 pp., illus.

Type Test of American Propeller Corp. A2891100 Blades in Aeroproducts A542-B2 Hub for Use on P-51H Airplane. E. K. Grimes. (Whirl Test No. 2071.) *U.S., Army Air Forces, Technical Report No. 5605*, July 11, 1947. 43 pp., illus.

Development and Test of an Armored Spinner for use on B-29 Propellers. E. L. Haley. (Whirl Test No. 1969.) *U. S., Army Air Forces, Technical Report No. 5604*, July 11, 1947. 5 pp., diagr.

Reference & Bibliography*

Personnel Directory of Aircraft & Engine Manufacturers. *Western Flying*, Vol. 28, No. 4, April, 1948, pp. 52–54, 56–58.

Rotating Wing Aircraft (34)

Goodyear's Steel Rotor Blade. Robert Mayne. *American Helicopter*, Vol. 10, No. 5, April, 1948, pp. 6, 7, 15, illus. 1 reference.

A design description giving the specifications and construction and assembly techniques. Stainless steel was selected to withstand adverse weather conditions and to provide a rigid, accurate profile. No weight penalty was involved in the use of steel. The blades were balanced at the quarter chord, and the first two sets tracked perfectly without adjustment when set at the same angle.

Helicopta. Henri A. de Villermont. *American Helicopter*, Vol. 10, No. 5, April, 1948, pp. 11, 16, diagrs.

The Helicopta 1, designed by the Helicopter Club of France, can be parked in an area approximately 21.3 feet × 8.2 ft. The 100-hp. Mathis engine drives twin-coaxial rotors through an axis that can be displaced to correct the position of the center of gravity. Rotor-blade pitch control is provided by a rotor governor and an engine governor. The aircraft is designed to cruise at 93 m.p.h. Maximum speed is estimated at 112 m.p.h., and range is expected to be 456 miles.

Rotor Blade Spoilers Aid Control. Scholer Bangs. *Aviation Week*, Vol. 48, No. 13, March 29, 1948, pp. 24, 25, illus.

The Landgraf H-2 has twin rotors mounted on either side of the fuselage and retractable tricycle landing gear. Spoilers on the rotor blades provide yaw control during hovering. The rotor blades maintain constant uniformity of pitch. Cyclic effect is supplied by the aileron on each blade. Power is transmitted from the single-engine transmission by tension-rod systems.

Newest Canadian 'Copter Puts Emphasis on Utility (Sznycer-Gottlieb SG Mark VI-D). *Aircraft and Airport*, Vol. 10, No. 3, March, 1948, pp. 31, 32, illus.

Canada's Bid in Helicopter Field. Irving Stone. *Aviation Week*, Vol. 48, No. 14, April 5, 1948, pp. 21, 22, illus. Data on performance, construction, and production plans for the Sznycer-Gottlieb SG Mark VI-D helicopter.

Westland-Sikorsky S-51. *Flight*, Vol. 53, No. 2049, April 1, 1948, pp. 355-358, illus., cutaway drawing.

AM84-Los Angeles. M. Berry. *American Helicopter*, Vol. 10, No. 5, April, 1948, pp. 8, 9, map.

The scheduled helicopter airmail service inaugurated by Los Angeles Airways, Inc., in October, 1947, and operating within 50 air miles in any direction from Los Angeles.

Sciences, General (33)

MATHEMATICS

Construction of Alignment Nomogram From Empirical Data. Lo-Ho. *Franklin Institute, Journal*, March, 1948, pp. 227–244, figs. 1 reference.

A graphical method of substituting a nomographic surface for a surface defined by a given equation or a given table of values. The nomographic surface possesses in common with the original surface four sections determined by two values of each of two of the variables determining the original surface. When proper rectangular coordinates are selected for the construction of the functional scale an additional common point may be established which greatly increases the accuracy of the nomogram. Examples are given of the method of procedure with experimental data. While the magnitude of the error of surface fitting cannot be predicted without calculating the specific case, a single alignment nomogram covering the ordinary ranges of the variables of practical problems may be expected to have an accuracy of about 99.5 per cent.

An Electronic Simultaneous Equation Solver. Edwin A. Goldberg and George W. Brown. *Journal of Applied Physics*, Vol. 19, No. 4, April, 1948, pp. 339–345, illus., diagr. 1 reference.

Stability, operation, and circuit and component features of an analog device that will give a direct solution of simultaneous linear equations without resorting to successive approximation methods. High-gain amplifiers are interconnected by a network whose elements correspond to the known coefficients and the constants of the system of equations. The network described can handle up to ten simultaneous equations. The same basic circuit can be used in devices for solving up to about 25 simultaneous equations. When the accuracy of the solution depends mainly on the characteristics of the analogue system rather than on the nature of the system of equations, the results will satisfy the individual equations within about 0.1 per cent.

Gyrograms for Simple Harmonic Systems Subjected to External Forces. V. Rojansky. *Journal of Applied Physics*, Vol. 19, No. 3, March, 1948, pp. 297–301, diagrs. 5 references.

A graphical method is described for the approximate integration of equations of the form $md^2x/dt^2 + kx = f(t)$, which arise in several branches of physics and engineering. The graphs, named "gyrograms," are an extension of the familiar "reference circle" used in representing simple harmonic motion. The method is applicable whenever $f(t)$ can be adequately approximated by a step function having a few steps.

Symmetrical Bi-Modal Frequency Curves. V. H. Gottschalk. *Franklin Institute, Journal*, Vol. 245, No. 3, March, 1948, pp. 245–252, tables.

Notes on Bernoulli's Method for Solving Algebraic Equations. Bernald Dimsdale. *Quarterly of Applied Mathematics*, Vol. 6, No. 1, April, 1948, pp. 77–81. 1 reference.

An amplification of Bernoulli's method which yields factors of the original equation and can be used with equations with complex coefficients. Convergence is slower than with Graeffe's process but, since it avoids factors whose roots are large powers of the roots of the original equation, this disadvantage is minimized if high-speed computing machinery is available.

The Approximate Numerical Solution of the Non-Homogeneous Linear Fredholm Integral Equation by Relaxation Methods. F. S. Shaw. *Quarterly of Applied Mathematics*, Vol. 6, No. 1, April, 1948, pp. 69–76, figs., tables. 4 references.

The equation for the deflection of a simply supported single-span beam subjected to both normal and end loads is solved by relaxation technique to illustrate the application of this method to the finding of an approximate numerical solution of the non-homogeneous linear Fredholm integral equation.

PHYSICS

A Mobile Laboratory for Acoustical Work. W. C. Copeland. *Journal of Scientific Instruments*, Vol. 25, No. 3, March, 1948, pp. 82–85, illus.

Designed to make field measurements of the acoustical characteristics of buildings, the determination of noise levels, the measurement of sound transmission through structures, and aircraft engine noise studies. Includes details of the vehicle, its interior layout, the apparatus installed, and methods of mounting to minimize damage by vibration.

Stress Analysis & Structures (7)

Problem Types in the Theory of Perfectly Plastic Materials. W. Prager. *Journal of the Aeronautical Sciences*, Vol. 15, No. 6, June, 1948, pp. 337–341, figs. 11 references.

The development of a stress-strain law applicable to the various problems arising in the behavior of perfectly plastic materials that are subject to slowly varying loads. A diagrammatic technique is used to study the states of stress and of residual stress. Within the domain of contained plastic deformation the instantaneous stresses in the structure can be found from the minimum principle of Haar and von Kármán since they depend only on the instantaneous load. If unloading is permitted, however, this principle must be replaced by another recently established by H. J. Greenberg, since the stresses now depend on the whole history of loading. The loading program of actual structures cannot be predicted in practice, but when the conditions discussed by Bleich in 1934 and Melan in 1936 with reference to trusses are fulfilled, the system "shakes down" to a state of residual stress that does not depend on the loading program and in which further variations of the load between given extremes are supported in a purely elastic manner. A minimum principle is conjectured by the author from which it may be possible to determine this state of stress. This diagrammatic treatment illustrates the difference between the behavior of elastic-plastic systems and completely elastic systems, and until a general stability theory for nonconservative systems becomes available, the simple system used here can probably be taken as typical of nonconservative systems.

The Nature of the Distortion of Swept-Back Wings. G. T. R. Hill. *Royal Aeronautical Society, Journal*, Vol. 52, No. 447, March, 1948, pp. 186–190, diagrs.

An analysis of the structural behavior of sweptback wings under loading that produces twist. The points of zero twist are found not to lie on an axis but on a curve arising at one of the spar attachments. For the sake of accuracy the term "locus of flexural centers" should be substituted for "flexural axis."

Dynamic Loads on Airplane Structures. E. S. Jenkins and C. D. P. Pancu. *Preprint, S.A.E. National Aeronautic and Air Transport Meeting*, New York, April 13–15, 1948. 42 pp., figs. 75 references.

The trend of airplane design toward greater structural flexibility and more rapid application of landing and flight loads increases the importance of the inertia forces associated with elastic distortion of the structure. The rigid-body load analysis has therefore become inadequate and dynamic-load analysis can be obtained by considering the airplane in vacuo as a system acted upon by external exciting and resisting forces peculiar to the loading system under consideration. By using data that are available on landing impact and gust loading, with information as to the lower modes of the aircraft structure, and by neglecting structural damping and coupling forces between the rigid body and elastic modes, approximate practical calculations may be obtained of the responses and critical stresses produced by the loads when they are assumed to act on the airplane only once. The general equations of motion are solved for responses and loads under the assumed conditions and applied to the calculation of this method to a large land airplane. The wing shear increments caused by a sudden gust are calculated and compared with design shears computed according to the present specifications of most Government agencies.

Tests of a $^1/_{17}$-Scale Model of the XBDR-1 Airplane in the NACA Gust Tunnel. Thomas D. Reisert. *U.S., N.A.C.A., Memorandum Report (Wartime Report No. L-539)*, February, 1944. 12 pp., illus. 5 references.

What Price Structural Testing? S. A. Gordon and G. E. Holback. *Preprint, S.A.E. National Aeronautic and Air Transport Meeting*, New York, April 13–15, 1948. 20 pp., illus., diagrs. 10 references.

The low weight requirement of modern aircraft has required the increasing use of marginal structures. This in turn has required the manufacturer to undertake more and more complicated structural testing. The extent of this testing varies from aircraft to aircraft and is determined primarily by the requirements of the purchasing agency, but a sound technical advertising policy also could well require the integration of a comprehensive testing program to prove the successful qualification of an airplane ahead of completion. A résumé of the types of tests performed, test techniques, facilities, space allocation, and the type and calibre of test personnel at The Glenn L. Martin Company shows how the Test Department is integrated into the company and how the test program and schedule is coordinated with production.

Landing-Impact Vibration of Aircraft. *U.S., National Bureau of Standards, Technical News Bulletin*, Vol. 32, No. 4, April, 1948, pp. 42–44, illus. 2 references.

A highly idealized dynamic model of an airplane was subjected to dropping tests to ascertain the validity of the assumption of an envelope of dynamic response factors proposed by Biot and Bisplinghoff for the estimation of the vibration of an aircraft structure arising during landing impact. On the model, the landing-impact force and the damping and spring force transmitted by the alighting gear were measured with pickups utilizing strain-sensitive wire, as were the bending moments in the wing. The acceleration at the fuselage was measured with a vacuum-tube acceleration pickup. The values obtained from Biot and Bisplinghoff's theory were 15 to 140 per cent greater than the measured values, thus giving a fair estimate generally on the safe side for the transient vibrations excited by a symmetrical landing. Dynamic-model tests made of unsymmetrical landings indicated that the discrepancies observed between calculated values and measurements made during actual landings were not attributable to wing flexibility.

Testing Landing-Gear; An American Drop-Rig; Wheels Spun in Reverse by Built-In Motors. *Aircraft Production*, Vol. 10, No. 113, March, 1948, p. 104, illus.

Bird-Impact Tests. E. R. Arbon. **I—Methods of Simulating Windscreen Collisions. II—Some Detailed Results of Investigation With the Rotating-Arm Test-Rig.** *Aircraft Production*, Vol. 10, Nos. 112, 113, February, March, 1948, pp. 39–42; 95–100; illus., diagrs. 1 reference.

I. In order to design the windshield of an aircraft to withstand the impact of collision with birds, the Bristol Aeroplane Company has set up a rotating arm with a release gear at its tip. Missiles used to simulate birds can be released at a maximum tangential velocity of 150 m.p.h. Similar tests conducted by others have used a rocket-propelled trolley on which the windshield is mounted, and a compressed air gun to project the bird.

II. Method of mounting a windshield panel and of obtaining a record of deflection under impact. Tests were made with acrylic-resin panels $^1/_4$, $^3/_8$, $^5/_8$, and $^3/_4$ in. in thickness. Deflections are plotted against the release velocities of the missiles, and the panel thickness is plotted against the velocity at which the missile penetrated the panel. Various panels of glass both plain and laminated and under various methods of mounting were tested to determine their penetration velocity and method of failure. Illustrations show failure of panels. Results of American investigations are summarized.

Design Charts for Longitudinally Stiffened Wing Compression Panels. Norris F. Dow. *Preprint, S.A.E. National Aeronautic and Air Transport Meeting*, New York, April 13–15, 1948. 46 pp., illus., tables.

Evaluation of the data obtained by the N.A.C.A. in the testing of longitudinally stiffened compression panels indicates that the maintenance of buckle-free surfaces on longitudinally stiffened compression panels does not conflict with the achievement of high structural efficiency. Very large diameter rivets very closely spaced are required to achieve a panel strength comparable to that of a panel having integral sheet and stiffeners. Hat-section stiffeners do not show higher structural efficiencies than Z-section stiffeners. Y-stiffened panels having ideal proportions do show higher structural efficiencies than ideally proportioned Z-stiffened panels. The optimum ratio of stiffener thickness to skin thickness depends on the design conditions. Design charts have been developed for 24S-T aluminum-alloy panels with extruded Y-section stiffeners from which it is possible to make direct selection of proportions to meet given values of the major design conditions, intensity of loading, skin thickness, and effective length of panel.

Stress and Distortion in a 45° Swept Box Beam Subjected to Bending and to Torsion. George Zender and Charles Libove. *U.S., N.A.C.A., Technical Note No. 1525*, March, 1948. 38 pp., diagrs.

Tip bending and twisting loads were applied to a box beam with 45° sweep, and the stresses and distortions were measured. The bending tests revealed a considerable build-up of normal stress and vertical shear in the rear spar near the fuselage for the swept-back box beam. No such marked effect accompanied torsion.

Shear Lag in a Plywood Sheet-Stringer Combination Used for the Chord Member of a Box Beam. Palamede Borsari and Ai-Ting Yu. *U.S., N.A.C.A., Technical Note No. 1443*, March, 1948. 57 pp., illus., tables. 10 references.

The theoretical and experimental investigation of shear-lag action presented is based on the concept of an idealized structure in which the main sources of strain energy of the real structure are maintained while the secondary sources are neglected, thus giving the idealized chord member infinite rigidity in the transverse direction. The test results justify the adequacy of the theory for practical design because the differences between theoretical and experimental results in the critical regions are smaller than would be expected from the usual irregular behavior of practical structures made of wood and plywood.

Bending of Rectangular Plates With Large Deflections. Chi-Teh Wang. *U.S., N.A.C.A., Technical Note No. 1462*, April, 1948. 34 pp., figs. 3 references.

Solves von Kármán's equations for thin plates with large deflections for special cases of rectangular plates of 1.5 and 2.0 length-width ratios under uniform normal pressure. The boundary conditions approximate panels with riveted edges under normal pressure greater than that of the surrounding panels. Center deflections (to twice the plate thickness), membrane stresses, and extreme fiber bending stresses are given as functions of the pressure. For small deflections, the results are consistent with those given by Timoshenko.

The Stresses in a Plate Containing an Overlapped Circular Hole. Chih-Bing Ling. *Journal of Applied Physics*, Vol. 19, No. 4, April, 1948, pp. 405–411, diagrs. 4 references.

The stress function in a plate containing a hole, whose rim comprises two equal circular arcs, is constructed by means of an even integral solution of a biharmonic equation expressed in bipolar coordinates. The parameters involved in the solution are determined by applying Fourier transforms to the given boundary conditions. From a development of the three cases (all-around tension, longitudinal tension, and transverse tension), an expression is obtained for the stresses along the rim of the hole and for the case of two complete circular holes tangent to each other. The numerical values of maximum stresses are tabulated.

A General Approximation Method in the Theory of Plates of Small Deflection. M. Zbigniew Krzywoblocki. *Quarterly of Applied Mathematics*, Vol. 6, No. 1, April, 1948, pp. 31–52. 10 references.

A method of determining the critical stresses of a plate which is entirely independent of the shape of the plate, but which is restricted by the type of loading. If there is no lateral load—i.e., if the forces act in the plane of the plate—the method is successful independently of whether the forces are distributed uniformly or not. If there is a lateral load, the method is not always successful, and there are cases in which it is not, at present, possible to find a particular solution or a fundamental integral of a nonhomogeneous linear partial differential equation of the fourth order. A function is first obtained which satisfies the linear partial differential equation of the fourth order for the deflection of the plate, but which does not satisfy the boundary conditions. Then a solution of this partial differential equation is found which satisfies precisely or approximately the boundary conditions. A method of S. Bergman is used to obtain a complete set of functions and convergent expansions in terms of them. The complete solution of the differential equation is given by a double series. The method of Bergman is used to make it possible to deal with variable coefficients in the linear homogeneous partial differential equation of the fourth order. In the illustration of the procedure, however, the critical stresses are calculated in a triangular plate which, for clarity, is loaded uniformly in its plane parallel to the x axis.

A Unified Theory of Plastic Buckling of Columns and Plates. Elbridge Z. Stowell. *U.S., N.A.C.A., Technical Note No. 1556*, April, 1948. 31 pp., figs. 10 references.

On the basis of modern plasticity considerations, a unified theory of plastic buckling applicable to both columns and plates is developed. For uniform compression, the theory shows that long columns that bend without appreciable twisting require the tangent modulus and that long flanges that twist without appreciable bending require the secant modulus. Structures that both bend and twist when they buckle require a modulus that is a combination of the secant modulus and the tangent modulus.

Buckling of a Column With Elastic Supports. T. H. Lin and K. S. Ching. *Journal of the Aeronautical Sciences*, Vol. 15, No. 6, June, 1948, pp. 347–350, figs. 2 references.

The elastic supports are assumed to provide only linear, not rotational restraints, to the bar for which a formula is derived to express its buckling in long column failure under compressive load. Increasing the spring constant of the supports increases the waves of buckling until there is one-half wave between each pair of supports. Increase of this constant, designated the maximum critical elastic constant, results in no further increase in the buckling load. An equation is given by which this constant may be calculated. The curves that plot the ratio of the buckling load to the Euler load against the spring constant for different modes of buckling facilitate the calculation of the buckling load when the spring constant of the elastic supports is known and the supports are equally spaced.

Ring Deflection. H. D. Tabakman. *Machine Design*, Vol. 20, No. 3, March, 1948, pp. 131–134, figs.

An analysis originally developed in the study of helicopter control mechanisms. Curves are given from which the constants may be determined to assist in the solution of a general equation for the deflection of any point on a ring subjected to loading normal to the plane of curvature of the ring. The analysis may be used in cases of symmetrical loading, unsymmetrical loading, and loading offset from the center of twist of the ring cross section.

The Behaviour of a Cylindrical Shell Under Axial Compression When the Buckling Load Has Been Exceeded. D. M. A. Leggett and R. P. N. Jones. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2190*, August, 1942. 12 pp., figs. 4 references. British Information Services, New York. $0.70.

An extension of the work of von Kármán and Tsien. The smallest load that will keep a thin cylindrical shell in a buckled condition is about one-third of that given by Southwell. Once the cylinder has buckled, the cylinder has only about one-quarter of its original stiffness, as long as the stresses remain within the elastic range of the material. These results agree well with experiment.

On a Problem in Plane Strain. H. J. Greenberg and Rohn Truell. *Quarterly of Applied Mathematics*, Vol. 6, No. 1, April, 1948, pp. 53–62. 1 reference.

A correction factor is obtained for Young's modulus which has been determined from a test in which it is assumed that the test bar is in simple compression, whereas, actually, because of frictional end effects, the end faces have not been free to be displaced in a direction normal to that of the applied force. In order to determine the relation between the force, the compression, and the Young's modulus, it is necessary to determine the strain energy of deformation of the bar. This is done to good approximation by applying the Prager-Synge method to the mixed boundary values that have been specified and obtaining the upper and lower bounds for the strain energy of deformation of the bar.

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Aeronautical Reviews

Books

Jet Propulsion in Commercial Air Transportation

By Robert E. Hage. Princeton, N.J., Princeton University Press, 1948. 91 pp., diagrs. $1.50.

A valuable reference for those who are interested in future design in air transport aircraft, *Jet Propulsion in Commercial Air Transportation* searchingly and effectively examines performance aspects of all powerplant characteristics as they relate to overall desires for air transportation. From this examination, the author is able to point out effectively the characteristics, comparative as well as detailed, which may be expected from turbojet and turboprop commercial transports. In examining these characteristics, it is of particular interest to note that the pertinent values studied are almost identical with those that must be considered with respect to most military designs of large aircraft. It would, therefore, appear to lend strength to the hope that transport designs in the future may be developed through joint commercial and military projects.

A particularly valuable feature of Mr. Hage's treatise is his examination of the manner in which jet transports would be applied to flight distances presently operated by five of the U.S. domestic airlines.

In several instances where cost curves of a comparative nature are shown, the author might have done well to stress the changing scene which is always present in any cost comparisons based on a current stage of technological development. For example, in one particular chart he shows the ton mile operating cost for pay load carried in a turbojet transport of $0.11 per ton mile as compared to $0.118 per ton mile for a transport powered by reciprocating engines. It might have been well to specify how such a comparison is particularly subject to change depending upon the comparative technical development of the reciprocating engines or turbojet engines.

Those reading *Jet Propulsion in Commercial Air Transportation*, will be rewarded by a refreshing view of what might be expected in the way of transport aircraft performance at such time as principles of jet propulsion, which are now being demonstrated so effectively military-wise, are applied to commercial operation.

R. Dixon Speas
Assistant to Vice-President,
Engineering Department,
American Airlines, Inc.

Scientific and Technical Abbreviations, Signs and Symbols

By O. T. Zimmerman and Irvin Lavine. Dover, N.H., Industrial Research Service, 1948. 476 pp., illus. $7.50.

This compilation begins well, with a general list of about 6,500 scientific and technical terms and their abbreviations and symbols. The field in which each term is used is usually indicated, and this general list is therefore a cross index of a good part of the book. The more general index, at the end, of twelve pages, containing about 600 terms, furnishes a guide to subjects and to specialized signs and graphical symbols, such as those of the *U.S. Weather Code*. Subjects covered include, besides aeronautics and aviation, the Greek alphabet, numerical prefixes, metric abbreviations, mathematics, and statistics; chemistry, chemical engineering, thermodynamics, heat flow, humidity, and radiation; mechanics, magnetics, hydraulics, acoustics, and illumination; mechanical drawings, materials of construction, and shop terms; electricity and electronics; mapping; railways, communications; meteorology; military terms; medicine, botany, and zoology; commerce, banking, and accounting; astronomy; Latin expressions, states, punctuation, and proofreading; and abbreviations of technical journals.

The list of abbreviations of technical journals is taken from *Chemical Abstracts*. As the field of both compilers is chemical engineering, the coverage of the book is especially good for that field and its related subjects.

Half of the standards used are reprinted by permission of the American Standards Association, and the National Advisory Committee for Aeronautics is the authority for the aeronautical symbols given. Equally authoritative sources are used in other fields. Sources are not indicated in all cases. This is the most comprehensive compilation of its kind at present available, and it can be recommended.

Maurice H. Smith
Curator Librarian, I.A.S.

For information on I.A.S. Library Service Facilities, see page 51

Statements and opinions expressed in Book Reviews are to be understood as individual expressions and not necessarily those of the Institute.

Tables of Supersonic Flow Around Cones

(Massachusetts Institute of Technology, Department of Electrical Engineering, Center of Analysis, Technical Report No. 1.) Washington, U.S. Govt. Printing Office, 1947. 555 pp., illus., diagrs. $3.50.

This volume supplies data by which the physical characteristics of the flow around a solid cone moving at a supersonic velocity can be readily determined, and with adequate precision for a general type of boundary conditions. The data include tables of supersonic flow of air around cones for fourteen semiapex angles ranging from 5° to 50°; a table giving the velocity component in terms of the Mach Number and the semiapex angle of the shock wave in terms of the Mach Number and the semiapex angle of the cone; a table giving the values of the velocity component and of Mach Number which separate different regimes of flow; tables of second-order discontinuities of the equation of flow; and a table of the change of the adiabatic constant and entropy across the shock wave as a function of the shock strength. Diagrams are included illustrating some physical properties of supersonic flow of air around cones.

Tables of Supersonic Flow Around Yawing Cones

(Massachusetts Institute of Technology, Department of Electrical Engineering, Center of Analysis, Technical Report No. 3.) Washington, U.S. Govt. Printing Office, 1947. 317 pp. $2.50.

Following an outline of the nonlinear hydrodynamical theory used as a basis for these computations, tables

are presented for the supersonic flow of air around slightly yawing cones of semiapex angles ranging from 5° to 50°, the shock-to-cone yaw ratio in terms of the radial velocity-component along the solid surface and the semiapex angle of the cone, and the coefficient of normal drag in terms of the radial velocity-component along the solid surface and the semiapex angle of the cone. Diagrams are included illustrating some physical properties of supersonic flow of air around slightly yawing cones.

Book Notes

ELECTRONICS

Microwave Transmission Circuits. Edited by George L. Ragan. (Massachusetts Institute of Technology, Radiation Laboratory Series No. 9.) New York, McGraw-Hill Book Co., Inc., 1948. 725 pp., illus., diagrs. $8.50. The emphasis in this volume is placed on principles and techniques, but a number of designs are presented, with performance data. Conventional transmission line theory is taken up first, and the use of transmission line calculators or impedance charts based on the equations resulting from this theory, modified in terms of electric and magnetic fields, is emphasized in later sections. Materials and techniques applicable to the fabrication of microwave transmission circuits are taken up next. The basic problem of connecting sections of transmission lines is discussed in the next four chapters, dealing with coaxial lines, wave guides, flexible coupling units and lines, transition units, and motional joints. Power dividers and switches are taken up in the following chapter. Discussion on variable impedance transformers, or timers, is included at some length although their usefulness is less in radio frequency circuits than in certain system applications and in laboratory experimental work. The final two chapters deal with the theory and design of microwave filters, covering work done late in the war along lines not previously exploited. Footnote references are included throughout.

GUIDED MISSILES

Tables for the Design of Missiles. By the Staff of the Computation Laboratory. Cambridge, Mass., Harvard University Press, 1948. lv, 226 pp. $9.00. These tables are designed to provide certain auxiliary functions permitting rapid calculation of the characteristics of such component solids of revolution as right circular cylinders, frustrums of right circular cones, ogives, and solids generated by the revolution of an area called a fillet. Definitions of the tabulated functions, the methods of computation, interpolation in the tables, and the use of the tables are explained in the introduction. The work was undertaken at the request of the U.S. Navy Bureau of Ordnance.

INSTRUMENTS

Principles of Servomechanisms; Dynamics and Synthesis of Closed-Loop Control Systems. Gordon S. Brown and Donald P. Campbell. New York, John Wiley & Sons, Inc., 1948. 400 pp., diagrs. $5.00. Intended for upper class and graduate students and for the designer, this text begins with an outline of the subject, followed by a formulation of the closed-loop problem in terms of elementary differential equations for which transient solutions are given and evaluated. This treatment is extended to make use of the Laplace transform, as a basis for a transfer function representation of the system. The transfer function is then developed as a tool in synthesis in terms of loci plots defining system behavior as a frequency spectrum. In conclusion, approximate methods are presented for determining the transient behavior from the frequency function. Problems and illustrative examples are included and a list of 73 references. The authors are members of the faculty at the Massachusetts Institute of Technology

MATERIALS

Haynes Alloys for High-Temperature Service. Kokomo, Ind., Haynes Stellite Co., 1948. 87 pp., illus., diagrs. The description of each alloy is accompanied by tables of its chemical composition, physical properties, and mechanical properties and by graphic comparison of tensile and stress-rupture properties. Data are presented on nine alloys, and on fabricating procedures for wrought high-temperature alloys, and age-hardening.

Magnetic Materials. F. Brailsford. London, Methuen, 1948. 156 pp., diagrs. 6s. The author's aim is to give a comprehensive outline of the present state of knowledge of ferromagnetic materials for the advanced student, the research worker, and those concerned with the technological applications of magnetic materials. Subjects discussed include ferromagnetism, properties and theory of single crystals, factors affecting magnetic properties, iron and silicon-iron alloys, nickel-iron and other alloys, and permanent magnet materials. References are included at the end of chapters.

METEOROLOGY

Weather Glossary. Compiled by Alfred H. Thiessen. (U.S., Weather Bureau, Publication No. 1445, August 1, 1946), Washington, U.S. Govt. Printing Office, 1946. 299 pp. $0.65. A list of approximately 2,000 terms used in meteorology and climatology based on a private compilation of Charles F. Talman, late librarian (1908–1936) of the United States Weather Bureau. Those terms that have found common use in meteorological writings during the past hundred years were selected from the original list, and those that have become important and commonly used in the last 10 years were added. Each term is defined according to the usage of American writers on meteorology and climatology, but different meanings given to them in other countries are noted. When appropriate, comprehensive explanations are given of concepts and phenomena. The value of this work is greatly increased by the references made throughout to more extensive treatments, and it should provide not only a glossary but an excellent index of sources.

OPERATIONS, COMMERCIAL

Survey on Ownership of Airlines. (Document No. 4954- AT/633.) Montreal, Can., International Civil Aviation Organization, 1948. Various paging. $0.75. Information is given on the ownership of about 240 air lines in 59 countries, as of November 30, 1947. Brief historical information for each air line is included. The associated companies, affiliates and subsidiaries of nine main air-line systems of the world are given in a separate section. The calcuated annual rate of aircraft miles is given for each operating airline in an appendix, with indications of government, private, or mixed ownership.

PHOTOGRAPHY

Elements of Photogrammetry. Earl Church and Alfred O. Quinn. Syracuse, N.Y., Syracuse University Press, 1948. 120 pp., illus., diagrs. $3.00. A revised and expanded edition of a textbook first issued in 1944, designed as an introduction to elementary photogrammetry. An excellent brief historical survey is followed by an outline of fundamental principles and their application to practical problems in photogrammetry.

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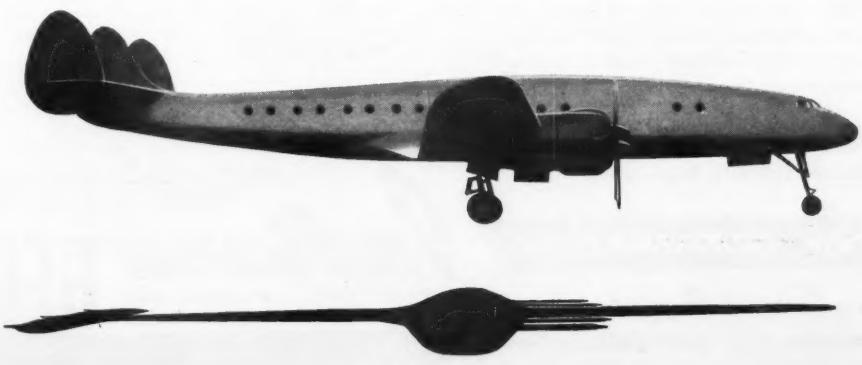

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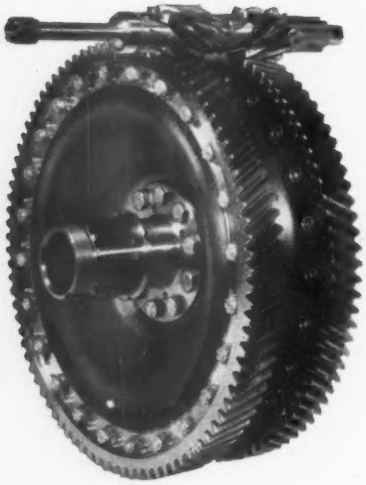

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The second part, comprising about two-thirds of the book, is devoted to practical mapping methods and is designed for use as a laboratory manual supplementing the theory of the first part.

SCIENCES, GENERAL

MATHEMATICS

The Differential Analyser. J. Crank. London, New York, Longmans, Green & Co., 1947. 137 pp., illus., diagrs. $2.50. Following a brief survey of the development of the differential analyzer, the construction of the machine which was completed at Cambridge, England, in 1939 is described. The design of a small scale model differential analyzer made mostly of Meccano parts is also discussed. Applications of the analyzer to equations arising in such fields as the laminar boundary layer, motion of a linear harmonic oscillator, and transients on a transmission line are taken up in detail, and a chapter is included on the mechanical solution of certain types of partial differential equations. In the final chapter the new differential analyzer under construction at the Massachusetts Institute of Technology is described. About 100 references to articles and books are included at the ends of chapters.

MECHANICS

Gears, Gear Production and Measurement. A. C. Parkinson and W. H. Dawney. New York, Pitman Publishing Corp., 1948. 260 pp., illus., diagrs. $4.50. Based on British and American sources and practices, this book is designed for the person having little or no background of basic knowledge of modern gear forms and manufacturing and measuring methods. Special reference is made to inspection methods. The first twelve chapters deal with spur gears, racks, the cycloidal system, and gears for clockwork mechanisms. Particular attention is paid to the geometry of the involute, and to the principles and practice of cutting spur, helical, bevel, spiral and worm gears. The final part of the book deals with gear measurement and testing, including the use of cylinders or balls for gear measurement, vernier and micrometer methods, and optical projection. Useful tables are included in an appendix.

Involute Gears. W. Steeds. London, New York, Longmans, Green & Co., 1948. 193 pp., illus., diagrs. $4.50. The author aims to present a balanced treatment of involute gearing for the use of engineering students, draftsmen, designers, and inspectors. Fundamental principles are presented in the first chapter, including American and British standards, and examples of calculation of toothed gears. Cutting and tooth finishing processes are next taken up, followed by a detailed treatment of the standard system of tooth proportions in use, including methods of measurement and inspection. The design and cutting of single and double helical toothed gears are next considered, and there is a final chapter on the principles of the calculation of the load capacity of gears.

STRESS ANALYSIS & STRUCTURES

ANC Bulletin: Vibration and Flutter Prevention Handbook. (U.S. Air Force-Navy-Civil Committee on Aircraft Design Criteria, ANC-12.) Washington, U.S. Govt. Printing Office, April, 1948. 26 pp., diagrs. This publication has been prepared in order to recommend acceptable procedures for performing flutter and vibration tests and analyses on aircraft. The first part, "Procedure for Aircraft Structural Vibration Survey," deals with the experimental determination of the dynamic reactions of the aircraft under forced vibations, embracing both conventional and rotary wing aircraft, and applicable also to aircraft of unconventional design. In the second part, "Methods of Flutter Prevention," design criteria are described which experience has shown to be effective in eliminating flutter. Cases are pointed out for which flutter calculations should be made instead of using empirical criteria. A third part on procedure for flutter analysis will be added later by amendment.

Proceedings of the Society for Experimental Stress Analysis, Vol. V, No. 2. Cambridge 42, Mass., Addison-Wesley Press, Inc., 1948. 153 pp. $6.00. Contents: The Measurement and Interpretation of Post-Yield Strains, Keith Swainger. On the Removal of Time Stresses in Three-Dimensional Photoelasticity, Max M. Frocht. The Development of a Technique for Testing Stiff Panels in Edgewise Compression, N. J. Hoff, Bruno A. Boley, and John M. Coan. An Evaluation of Some Approximate Methods of Computing Landing Stresses in Aircraft, Elbridge Z. Stowell, John C. Houbolt, and S. B. Batdorf. Equivalence of Photoelastic Scattering Patterns and Membrane Contours for Torsion, D. C. Drucker and M. M. Frocht. A Three-Component Force Recorder, Arthur R. Anderson. Three-Dimensional Photoelastic Analysis by Scattered Light, Ernesto M. Saleme. Stress Distribution Around a Hole Near the Edge of a Plate Under Torsion, R. D. Mindlin. Response of Damped Elastic Systems to Transient Disturbances, R. D. Mindlin, F. W. Stubner, and H. L. Cooper. Electric Strain Gage Analysis of Fifty-Foot Hortonsphere, Given Brewer. A Pendulum Analyzer for Mechanical Transients, J. H. Macduff. A Strain-Gage Balance System for a Supersonic Wind Tunnel, R. M. Mains. The Photo-Grid Process for Measuring Strain Caused by Underwater Explosions, D. D. MacLaren. Some Evaluations of Stresses in Aneroid Capsules, H. J. Grover and J. C. Bell. Allowable Stresses for Steel Members of Finite Life, G. C. Noll and M. A. Erickson. Theoretical and Experimental Investigation of Buckling Shock Mount, Charles E. Crede and Sheldon E. Young.

Announcing a New Journal Department . . . Readers' Forum

It has been suggested by several members of the I.A.S. Editorial Committee that the *Journal* open a special department to fill the need for the more immediate communication of essential results of research in the greatly expanded and accelerated fields of the aeronautical sciences. Therefore, it has been decided to establish a new department, the "Readers' Forum," which will include letters to the editor for the quick publication of (1) brief reports of important findings in aeronautical sciences and (2) discussions of papers published in the *Journal*.

Specifications for Submission of Material

(1) All letters should be accompanied by a suggested short title, giving some indication to the reader of the subject under discussion.

(2) These letters should not exceed 800 words in length.

(3) Publication will be completed 6 to 8 weeks after receipt of the material.

(4) The Editorial Committee will not hold itself responsible for the opinions expressed by the correspondents, and no proofs will be sent to the authors.

(5) All letters should be double-spaced.

It is hoped that the new department may be started with the January, 1949, issue of the *Journal*. Contributions should be sent to:

Editor, Journal of the Aeronautical Sciences
2 East 64th Street
New York 21, New York

Members Elected

(*Continued from page 16*)

Van Dyke, Rudolph Daniel, Jr., B.S.E. (Ae.), Engineer & Test Pilot, Ames Aero. Lab., N.A.C.A.

Wead, Robert Kasson, Research Engineer, Consolidated Vultee Aircraft Corp.

Weller, Peter Anthony, B.S. in Ae.E., Chief Engineer, Stalker Development Co.

Wilson, George William, Sr., Experimental Officer, Aero. Research & Development, Ministry of Supply (Canada).

Winch, Stanley G., B.S. in M.E., Sales Engineer, Wright Aeronautical Corp.

Wood, George Price, Jr., M.A., Physicist & Aero. Research Scientist, Langley Mem. Aero. Lab., N.A.C.A.

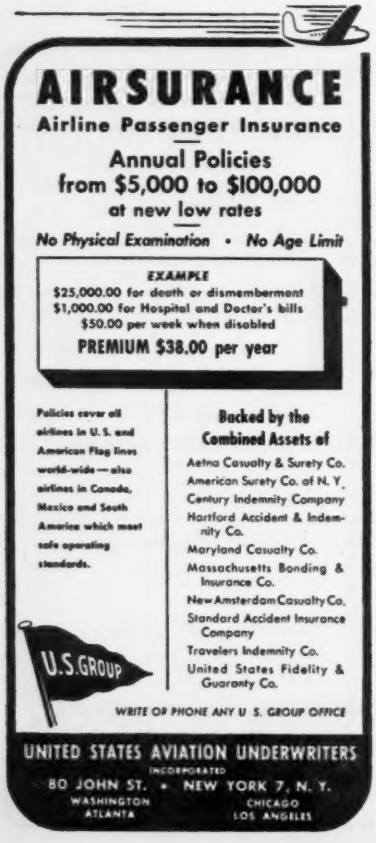
Transferred to MEMBER Grade

Adler, Alfred Aron, B.S. in M.E., Research Aerodynamicist, Cornell Aero Lab.

Berner, Robert Lewis, B.S. in E.E., Design Specialist, Thermal Design Section, The Glenn L. Martin Co.

Bogdonoff, Seymour Moses, B.S. in Ae.E., Research Associate, in Charge of Supersonic Tunnel, Aero. Lab., Princeton Univ.

Crofut, Edward G., Dir. of Engineering, Aerolab Development Co.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Gottlieb, Selma Gertrude, B.A., Asst. Chief Engineer, Sznycer & Gottlieb.

Martin, Edward Francis, Jr., Student, University of Calif.

Mayne, Robert, B.S. in E.E., Mgr., Aerophysics Dept., Goodyear Aircraft Corp.

Pusin, Herman, M.S. in Ae.E., Development Design Engineer, The Glenn L. Martin Co.

Smith, Larz McClellan, B.S. in Ae.E., Sr. Structures Engineer, Curtiss-Wright Corp. Structures Dept. (Columbus Plant).

Thurlow, David Warren, B.S. in M.E.

Voyles, James Homer, Jr., B.S. in G.E., Capt., Assigned Hq. Air University Maxwell A.F. Base, Montgomery, Ala., with duty at The Ohio State University for Graduate work in Industrial Production Engineering.

Walley, William R., B.S. in Ae.E., Aerodynamicist "A," Performance Group, Aerodynamics Section, Douglas Aircraft Co., Inc.

Elected to Associate Member Grade

Cahn, Edgar B., V.P. and Chairman of the Board, Airways Engineering Consultants Inc.

Harder, John Worthington, Aviation Correspondent, *The Aeroplane*, Temple Press Ltd. (London); Flight Instructor & Charter Pilot, Westair, Inc.

Kearns-Batchelor, William Hugh, Sr. Aircraft Inspector at A. V. Roe Canada Ltd., Dominion Govt. of Canada, Dept. of Transport, Civil Aviation Div.

Lippard, George Herman, Weight & Balance Engineer, Piasecki Helicopter Corp.

Mezenes, Peter Emmanuel, Supt. Engineering Dept., Air India Ltd. (Madras).

Tuntland, Paul Elliott, Research Test Pilot, Aerophysics Institute, Inc.

Woehr, Frank, M.A., Principal, Manhattan High School of Aviation Trades, Board of Education (New York City).

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Brom, Joseph R., M.S. in Ae.E., Aerodynamicist (Govt. Project), University of Chicago.

Cochran, Alexander McKie, President, Fogging & Dusting Service, Inc.

Des Clers, Bertrand, B.Sc., Lab. Asst., Aeronautics Dept., The Johns Hopkins University.

Gullstrand, Tore R., C.E., Deputy Prof. of Aeronautics, Royal Institute of Technology (Sweden).

James, Vincent, Aircraft Technician, Air Services of India, Ltd. (India).

Jarrett, Thomas William, B.M.E., Sr. Mech. Engineer, Jet Engine Div., Packard Motor Car Co.

Leabu, Victor Francis, B.S. in Ae.E., Structural Designer, Giffels & Vallet.

Marshall, Edmund Valentine, M.S. in Ae.E., Test Engineer, Power-plant Design Test Group, Chance Vought Aircraft Div., United Aircraft Corp.

Maeder, Paul F., Dipl. Ing., Asst. Prof., Brown University.

Marchal, Raymond, Aero. Engineer C., Stampe & Renard (Belgium).

Melrose, George B., Jr., M.S. in Aero., Aerodynamicist, Bell Aircraft Corp.

Miller, Edward P., B.A.Sc., Asst. Aero. Research Engineer, Applied Mechanics Section, Cornell Aero. Lab.

Niehaus, Owen Quintin, Chief Test Pilot, Bell Aircraft Corp.

Vale, Robert E., B.Sc., Stress Analyst, A. V. Roe Canada Ltd.

Wattson, Robert K., Jr., B.S.M.E. (Aero.), Part-time Asst. in Aero. Engineering, Massachusetts Institute of Technology.

Transferred from Student to Technical Member

Baskin, William Hayes, B.Sc., Draftsman "B," Consolidated Vultee Aircraft Corp.

Bodiford, Robert G., Ae.E., Graduate Student, Georgia Institute of Technology.

Brugge, Robert Morse, B.S. in Ae.E.

Carros, Robert Joseph, B.Ae.E., Aero. Engineer, Langley Mem. Aero. Lab., N.A.C.A.

Ciavolella, Joseph, Draftsman, Fairchild Aircraft Div., Fairchild Engine & Airplane Corp.

Cross, Richard Irwin, B.S. in M.E., Engineer-in-training, The Goodyear Tire & Rubber Co.

Fenstermacher, George Perry, B.Sc. in Ae.E., Engineer, Engineering Div., Chrysler Corp.

Fiore, Anthony William, Ae.E., Grad. Student, University of Cincinnati.

Flynn, Gladys (Miss), B.A., Research Librarian, Sikorsky Aircraft Div., United Aircraft Corp.

Gibler, David Lee, B.S. Naval Science & Tactics, Draftsman "B," Douglas Aircraft Co., Inc.

Glen, Cornelius Leonard, Jr., B.S. in Ae.E., Draftsman, Fairchild Aircraft Div., Fairchild Engine & Airplane Corp.

Gunn, Clem Oliver, Jr., B.Ae.E., Student, Georgia Institute of Technology.

Hardy, Maurice Miller, B. of Naval Science, Draftsman "B," Douglas Aircraft Co., Inc.

Hill, Elliot Grant, B.S.Ae.

Huntington, Hugh, Jr., B.S. in Ae.E., Design Engineer, Northrop Aircraft, Inc.

Klepinger, Richard H., Ae.E., Aero. Engineer P-3, Wright Field (Dayton).

Kohlenberg, Kenneth William, B.S. in Ae.E., Sr. Detailer, McDonnell Aircraft Corp.

Kunst, Arnold Edward, B.S. in M.E.

Laundis, John W., Draftsman (Columbus Plant), Curtiss-Wright Corp.

Lee, Russell Entrekin, Flight Engineer T.W.A.

Marth, Verlyn G., Missile Flight Test Analyst, Consolidated Vultee Aircraft Corp.

Matarazzo, Gerald J., Jr., Sr. Draftsman—Jr. Engineer, American Machine & Foundry Co.

Mitchell, Charles Robert.

Montany, Eugene Robert, B.Ae.E., Research Engineer—Aerodynamics, Curtiss-Wright Corp.

Montgomery, Bernard Paul, B.S.Ae., Engineer (Design), McDonnell Aircraft Corp.

Morgan, John J., B.S. in Ae.E., Technical Computer, McDonnell Aircraft Corp.

Morse, David Mitchell, Ae.E., Design Operations Engineer, Chance Vought Aircraft Div., United Aircraft Corp.

Nelson, Roy Paul, B.S. in Ae.E., Testing Engineer, Crane Co.

Paszli, Louis J., B.S. in Ae.E., Landing Gear Stress Engineer, Bendix Aviation Corp.

Quermann, Thomas Richard, B.S. in M.E., Asst. Project Engineer, Sperry Gyroscope Co.

Sabo, Joseph Alexander.

Schenbeck, Robert Edwin, B.Sc., Draftsman "B," Douglas Aircraft Co., Inc.

Seipp, George Anthony, B.S. in Ae.E., Structural Engineer, Fairbanks Morse & Co.

Shibata, Harry Hiroyuki, B.Sc.

Spraker, Wilbur Allen, Jr., B.S. in M.E., Analytical Engineer, Technical & Research Dept., Pratt & Whitney Aircraft Div., United Aircraft Corp.

Springer, Robert E., B.Ae.E., Facilities Engineer, Aero. Lab., University of Minnesota.

Steele, Chester N., B.S. in Ae.E., Mathematician, Aerodynamics Dept., Consolidated VulteeAircraft Corp.

Stevenson, James William, Jr., Mechanic, American Airlines System.

Taylor, William Ellsworth, B.Ae.E., Research Engineer, United Aircraft Corp.

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Vetter, Leo Joseph, B.S. in Ae.E., Designer & Draftsman, Douglas Aircraft Co., Inc.

Wall, Edward Lytle, B.S. in Ae.E., Sr. Detailer, McDonnell Aircraft Corp.

Warakomski, John, B.S., Sr. Detailer, McDonnell Aircraft Corp.

Wennagel, Glenford J., B.Ae.E., Static Test Lab., Grumman Aircraft Engineering Corp.

Wesbecher, James Joseph, B.S. in Ae.E., Jr. Test Engineer, Pratt & Whitney Aircraft Div., United Aircraft Corp.

Withee, Joseph Richard, Jr., B.Ae.E., Aero. Engineer, Flight Propulsion Research Lab., N.A.C.A.

Wymbs, Norman Elwood, B.S.Ae.

Yousoufian, Hrant Harry, B.Ae.E., Research Fellow, Polytechnic Institute of Brooklyn.

Zachow, Arnold August, B.Ae.E., Design Engineer, Bell Aircraft Corp.

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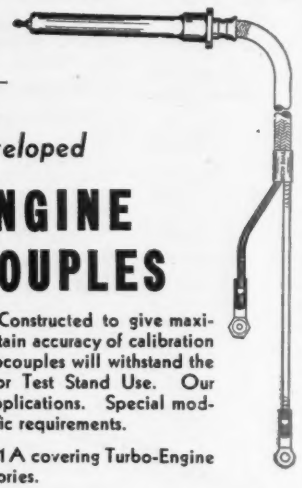

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Personnel Opportunities

This Section is for the use of individual members of the Institute seeking new connections and organizations offering employment to aeronautical specialists. Any member or organization may have requirements listed without charge by writing to the Secretary of the Institute.

WANTED

Research Personnel—Employment opportunities are for engineering graduates interested in subsonic or supersonic aerodynamic testing and research. Employees desiring to undertake graduate study can arrange their working hours accordingly. Write to Department of Aeronautical Engineering, University of Washington, Seattle 5, Wash.

Instructors—One opening for an aeronautical engineering graduate with industrial experience appropriate for teaching stress analysis and aircraft structures. Other openings are available for engineering graduates who will teach engineering drawing and engineering mechanics. Part-time employment permitting intensive graduate study can be substituted if applicant wishes to obtain an advanced degree. Write to Department of Aeronautical Engineering, University of Washington, Seattle 5, Wash.

Aeronautical Engineers—Fairchild Aircraft Division, Hagerstown, Md., has vacancies in its Engineering Department at Hagerstown and also Branch Engineering Office, Washington, D.C., for engineering draftsmen, layout engineers, aerodynamicists, electrical engineers, structures and research engineers (with Ph.D. in Math. or Physics). For immediate details write Employment Manager, Fairchild Aircraft Division, Hagerstown, Md.

Jet Propulsion Engineer—Civil Service position open in Pasadena, Calif., in jet propulsion research and development field. An aeronautical engineer with strong thermodynamic and chemistry background preferred, although chemist or chemical engineer with some aeronautical engineering experience or experience with explosives could qualify. Engineering degree and 4 years' experience or equivalent necessary. Salary $5,905.20 per annum. On applying please give brief sketch of personal qualifications, education, and experience. Address: Bureau of Aeronautics Representative, 15 S. Raymond Ave., Pasadena 1, Calif.

Physicist P-5—To head applied research and experimental group in rocket ballistics. Thorough training in theoretical physics and good understanding of experimental methods essential. Must be able to guide and vigorously prosecute programs involving both theoretical and experimental studies and keep them properly related. Salary $5,904 per annum. Apply to J. T. Dale, Navy Department, Joint Board of U.S. Civil Service Examiners, 1030 E. Green St., Pasadena 1, Calif.

Physicist P-5—To head ballistics measurement and development unit. Requires experience in developing instruments for measuring physical quantities. Must be able to analyze and foresee needs for new methods of measuring ballistics quantities. Experience in radar, magnetic, photographic, and optical development desirable, though no one type is essential. Salary $5,904 per annum. Apply to J. T. Dale, Navy Department, Joint Board of U.S. Civil Service Examiners, 1030 E. Green St., Pasadena 1, Calif.

Physicist or Aeronautical Engineer P-5—To head group responsible for the operation of experimental facilities for the free-flight and wind-tunnel testing of rocket and guided missile models. Thorough knowledge of supersonic wind-tunnel techniques essential, and some acquaintance with techniques for obtaining force measurements in free flight desirable. Salary $5,904 per annum. Apply to J. T. Dale, Navy Department, Joint Board of U.S. Civil Service Examiners, 1030 E. Green St., Pasadena 1, Calif.

Physicist or Aeronautical Engineer P-5—To head applied research group in aerodynamics and stability of guided missiles. Must have a good theoretical background in supersonic aerodynamics and be capable of directing performance and stability analyses and the design of the aerodynamic envelopes of guided missiles. Salary $5,904 per annum. Apply to J. T. Dale, Navy Department, Joint Board of U.S. Civil Service Examiners, 1030 E. Green St., Pasadena 1, Calif.

Physicist or Aeronautical Engineer P-5—To head applied research group in aerodynamics and stability of rockets. Must have a good theoretical background in supersonic aerodynamics. Some knowledge and experience in rockets and ballistics desirable but not essential. Salary, $5,904 per annum. Apply to J. T. Dale, Navy Department, Joint Board of U.S. Civil Service Examiners, 1030 E. Green St., Pasadena 1, Calif.

Aerodynamicists—The University of Michigan Aeronautical Research Center at Willow Run Airport, Ypsilanti, Mich., has several openings on its research staff for aerodynamicists with experience in theoretical supersonic aerodynamics for work with supersonic missiles. Positions require good academic background and sound knowledge of dynamics and applied mathematics. Advanced degree desirable. Applicants are invited to send a complete outline of their academic qualifications and experience to the Personnel Office, University of Michigan, 208 University Hall, Ann Arbor, Mich.

Mathematician—The University of Michigan Aeronautical Research Center at Willow Run Airport, Ypsilanti, Mich., has an opening on its research staff for a mathematician with some familiarity with problems of rocket flight and analysis of trajectories. Advanced degree essential. Applicants are invited to send a complete outline of qualifications and experience to the Personnel Office, University of Michigan, 208 University Hall, Ann Arbor, Mich.

Aerodynamicists and Aeronautical Engineers—Positions available for highly qualified technical personnel with good theoretical or experimental background to engage in development of facilities and model test work in stability, control, high-speed, and supersonic aerodynamics. Projects include new models of piloted and pilotless aircraft, new wind tunnels and associated equipment, and advanced testing techniques. Salary in accordance with qualifications and Civil Service regulations. In reply, please give brief summary of personal qualifications, education, and experience. Address—Director, David Taylor Model Basin, Washington 7, D.C.

Professor—The College of Engineering, West Virginia University, has an opening for a Professor of Aeronautical Engineering and Head of Department. The salary for a properly qualified man is $6,000. Interested parties may contact R. P. Davis, Acting Dean, College of Engineering, West Virginia University, Morgantown, W.Va.

Flutter Engineer—Aeronautical Engineering graduate with several years of experience in flutter and vibration problems needed for work on advanced military aircraft. Address reply to Engineering Personnel Office, North American Aviation, Inc., Municipal Airport, Los Angeles, Calif.

895. Research Scientists—Experienced research scientists with advanced degrees and experience in applied physics, aerodynamics, thermodynamics, mathematics, or chemistry to perform supervisory research and act as permanent consulting group to engineering laboratory. Excellent opportunity for men with right qualifications. Salary, $8,000–$14,000 bracket.

894. Aeronautical Engineer—With Master's Degree to head aeronautical option in mid-western college. Should preferably have teaching and industrial experience. Salary open.

893. Engineers—West Coast airplane manufacturer has need for additional aerodynamicists, stress analysts, and airplane control system designers having experience with servomechanisms and automatic pilots.

885. Engineer-Salesman—To head up engineering or sales, or both, of long-established company manufacturing aircraft fuel, oil, air, and water injection pumps, valves, etc. Proper man can qualify as Chief Engineer or Sales Manager. Must be experienced in design and manufacture of these products, be conversant with Air Force and Navy Requirements, be alert to sales opportunities, and have good knowledge or experience in sale of these products. Excellent prospects for profitable future. On initial application please give complete information, including former employers, duration of employment, responsibilities, name of immediate supervisor, salary, etc. Location—Middle West.

The number preceding the notices represents the Box Number of the Institute of the Aeronautical Sciences to which inquiries should be addressed.

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902. Engineer—B.Sc. Ae.E., M.S. in Ae.E., specializing in propulsion, aerodynamics, and research techniques for supersonic flight. Recipient of three scholarship awards for outstanding work as an undergraduate. Reads and speaks French and German. Has done tutoring in physics and aeronautics. Three years' experience in research, development, and manufacture planning for aircraft instruments and a subsonic wind tunnel. Two years' experience with the A.A.F. as an aeronautical engineer on the headquarters staff of an overseas air force. Duties of this position included personal responsibility for maintenance supervision of all troop-carrier aircraft, as well as P-38 fighters, and research into combat modifications to both types of aircraft. Desires engineering position in propulsion or aerodynamic research or as a teacher of these subjects.

901. Aeronautical or Mechanical Engineer.—B.S. degree in Aeronautical Engineering. Graduate student for 1½ years in Aeronautics and Applied Mechanics. Two years' experience in the aircraft industry as a senior draftsman and aerodynamicist. Desires a position in stress analysis or aerodynamics and other related engineering work. Will accept position anywhere in the U.S. or abroad.

900. Aeronautical Engineer—Age 36; married. Two and one-half years with major aircraft

manufacturers as a specialist in weights and balance, technical writing, technical reports, and specifications writing. Able to handle and familiar with machine-shop practice. Holds a valid A. & E. license from the C.A.A. Has had approximately 12 years' all-around experience on transport and private-type aircraft as a technician. Would like position as technical reports writer, liaison, and/or maintenance engineer.

899. Engineer—Housing requires a change of position this fall. Associate Professor, Aeronautical Engineering; age 32; large mid-western university. Technical Director of sponsored powerplant research project. Industry or university position considered. Rental housing for family of five a necessity.

898. Engineer—B. Aero. E., M. Aero. E. Three and one-half years' industrial experience, including over 2 years' aerodynamics in wind tunnel, performance, air loads, stability, and control. Past 1½ years as experimental research engineer with East Coast precision instrument corporation. Duties included design and operation of experimental equipment. Graduate studies include aerodynamics, both theoretical and applied, aviation gas turbines, stress analysis, dynamics of aircraft. Would prefer teaching position in New York area but will travel if necessary.

897. Associate Professor—Ph.D. in Applied Mechanics, degree in Aeronautical and Mechanical Engineering. Five years' experience in industry and research; head of structures department with aircraft manufacturer. Wishes to obtain university position teaching theoretical graduate courses in applied mechanics or mathematics, with opportunities for research.

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891. Professor—Professor of Aeronautical Engineering desires change to position in more favorable climate. Industrial experience as chief aerodynamicist. Papers on dynamics and thermodynamics. Advanced degree.

890. Aeronautical Engineer—B.A.E. New York University, 1940. Broad experience in general design and research as group leader. Three years as project engineer in jet propulsion research and experimental helicopter design. Available New York area on part-time or consulting basis only.

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883. Aeronautical Engineer—B.A.E. Cum Laude. Five years' experience in aeronautical research, including compressible flows, propeller research, wind-tunnel fan and ducted fan design. Desires position in research near or with university providing opportunity for work toward advanced degrees.

882. Engineer—Ten years' responsible experience in production and development of electromechanical equipment. Excellent relationship with factory personnel and customers. Especially interested in costs. Age 37; engineering degree; employed at present. Prefers association with small organization.

881. Aviation Writer-Editor—Fifteen years of practical experience on newspapers, national and technical magazines, and special publications. Seeks connection with publisher or in the industry in public relations capacity. Especially good connections in the magazine field for latter assignment. Age 35; married.

880. Engineer—Brazilian; Rensselaer Polytechnic Institute graduate; speaks English fluently; resides in Rio de Janeiro. Desires to work with, or for, an American company in a technical or administrative capacity.

879. Research Aerodynamicist—Six years' experience includes teaching, Wright Field experience in performance and missile study, consulting on missile projects. At present employed in

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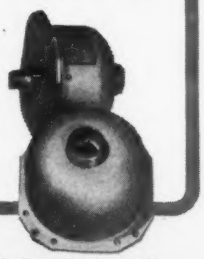

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877. Stress Analyst—B.Ae.E.; married. Employed by large aircraft manufacturer on West Coast for past 4 years, but now seeks location within 150 miles of New York City. In present classification for year and a half. Previous experience in structural design group and structural test.

876. Aeronautical Engineer—B.Ae., University of Detroit. Canadian citizen; age 28; married. Seven years' general experience in such phases as: design of aircraft components, shop, and ground equipment; structural analysis; plant layout; technical analysis and administration. Last 5 years as service engineer with large Canadian air line on maintenance and operational problems. Familiar with C.A.A. and British requirements. Seeks wider experience in the aeronautical or related fields. Will locate anywhere in Canada, United States, or abroad.

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874. Power Plant Engineer—Thermodynamicist—Thoroughly experienced in power-plant installation thermodynamics, reciprocating and jet engines after-burning, cycle analysis, compressible flow, air conditioning, pressurization, fuel, lubrication systems, engine and tailpipe cooling, supersonic wind-tunnel design. Available on permanent or consulting basis.

872. Technical School Executive—Sixteen years' executive, administrative, and teaching experience in North and South America. B.S. Degree in Mechanical Engineering. Working knowledge of all phases of school operation. Desires managerial position in private, Government, or company-operated technical training program. Aviation activity preferred.

868. Management or Administration—A.B. degree, University of Pennsylvania; 28 years old; single. Major in political administration, courses applicable to business administration. Courses in industrial engineering including industrial relations, business and Government, organization and organizational structure. Aeronautical engineering courses in elementary aerodynamics, performance calculation, aircraft drafting, and engineering. Over 4 years in aircraft testing in present position. Desires permanent position on junior level in management or administration with opportunity or advancement. Philadelphia, Pa.

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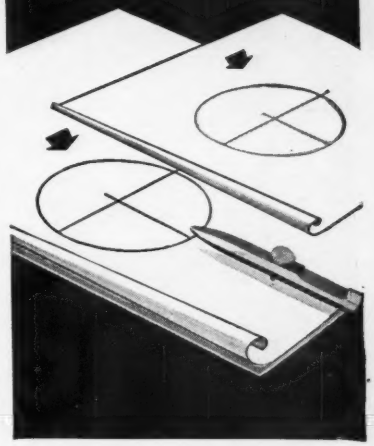

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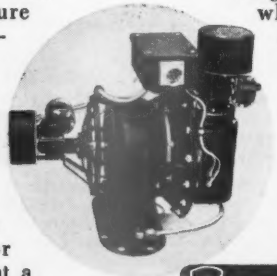

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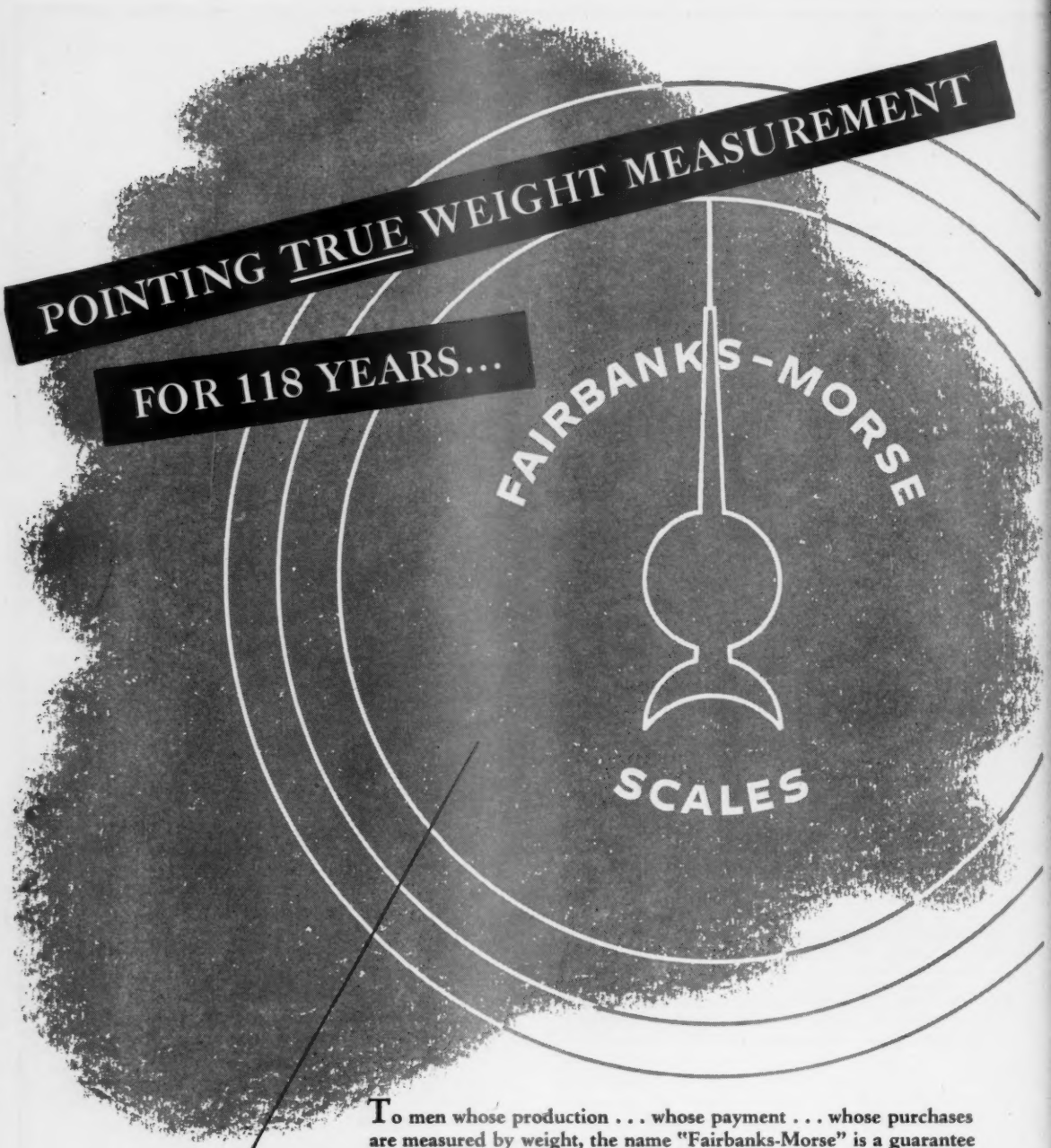

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